Application of Lidar in Comparison of Wind Speed and Wind Direction Meters in Wind Power Field

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Abstract. Wind speed and wind direction indicator in wind turbine is a very important component in the whole power generation system. Inaccurate or incorrect sensor signals will not only make the wind turbine inefficient, but also affect the safe operation of the wind turbine and the life of other components. After the warranty period, after the wind power plant takes over the wind power operation and maintenance, the maintenance demand of the above sensors will be greatly increased. In this project, numerical simulation is used to evaluate the status of wind speed and direction indicator, so as to automatically capture data, compare data, and generate correction coefficients.

Keywords. Wind Speed; Wind Direction; Comparison; Indicator; Wind Turbine

1. Background

Wind turbines rely on dozens of micro sensors to monitor their operating conditions, and monitor the structure, internal sensitive locations and system components of wind turbines at any time to ensure efficient and safe operation. Among them, wind speed and direction indicator, vibration, speed, temperature, inclination and other sensors are very important components in the entire power generation system. Inaccurate or incorrect sensor signals will not only make the fan inefficient, but also affect the safe operation of the fan and the life of other components [1].
In addition, the fan manufacturer is mainly responsible for the calibration of the fan sensor, which is mainly carried out by sampling inspection [2]. The purpose is to meet the requirements of the contract terms, not to consider the safe and efficient operation of the unit. With the expiration of the warranty period and the improvement of the importance attached to the above work by major power generation groups, the demand for fan sensor maintenance is increasing in a blowout manner [3]. However, the current situation of wind power generation enterprises is that there are few operation and maintenance personnel, and the professional coverage of personnel is incomplete, which makes it difficult to achieve a comprehensive assessment of wind turbine sensors [4].

2. Necessity of technical transformation

Wind speed and wind direction indicator, vibration, temperature, inclination and displacement sensor in wind turbine are very important components in the whole power generation system [5]. Inaccurate or incorrect sensor signals will not only make the fan inefficient, but also affect the safe operation of the fan and the life of other components. After the warranty period, after the wind power plant takes over the wind power operation and maintenance, the maintenance demand of the above sensors will be greatly increased. However, the current situation of wind power generation enterprises is that there are few operation and maintenance personnel and the personnel coverage is incomplete.
For the wind speed and direction indicator, Doppler lidar technology is used in this project to achieve on-site and real-time calibration without dismantling the wind speed and direction indicator. At the same time, combined with numerical simulation technology, the deviation of the wind speed and direction indicator itself and the data deviation affected by the impeller are quantified, and finally the wind speed and direction indicator is calibrated in situ, and the unit power generation efficiency is improved by correcting the data deviation of the wind speed and direction indicator.

3. Main problems solved through technical transformation

This project will realize the transformation from the traditional sensor inspection mode to the judgment of the real-time working state of the sensor. With the goal of the ultimate safe and efficient production of the object, it will realize the real object-oriented measurement and make the measurement serve the object.

The purpose of this technology is to develop a sensor status assessment technology to meet the actual needs of the wind power generation industry, change the sensor status assessment work from labor-intensive to intelligent, reduce manual operation, reduce the difficulty of implementation, improve operability, solve the contradiction between the high requirements for status supervision in existing wind power generation and the difficulties in actual implementation, and fill the technical gap for the wind power generation industry.

This project is mainly aimed at wind power plants or power generation groups that are about to or have expired their warranty period. When the rights and responsibilities of the wind turbine are transferred after the warranty period, the wind power plant or the power generation group will pay more attention to the safety of the operating state of the unit, and will carry out the annual sensor calibration in accordance with relevant regulations. Therefore, there is an urgent technical demand.

4. Scheme demonstration

This technology is based on Doppler lidar technology, combined with numerical simulation model analysis, to achieve the in-situ static and dynamic calibration of wind direction and anemometer of wind turbine, and evaluate the real working state of wind speed and anemometer of unit. In addition, the mobile multi in one comparison sensor is arranged in the fan room to realize the sensor comparison status evaluation without disassembling the original sensor.

Doppler lidar is used to retrieve the radial wind speed by detecting the backscattered signal of aerosol particles and the Doppler frequency shift of the local oscillator of the system. It has the characteristics of high spatial and temporal resolution and high measurement accuracy. It is one of the most effective means to measure the fan performance curve at present, and has been applied to the wind measurement in the early stage of the project, the fan curve test and the post evaluation of wind farms at home and abroad.

At present, this technology has not been used in the field of wind turbine anemometer measurement. Due to installation error, mechanical wear and the influence of wake, the error of traditional anemometer will be caused. However, it is impossible to judge whether the deviation is caused by equipment failure or blade wake simply by comparing the lidar measurement results with the unit data.

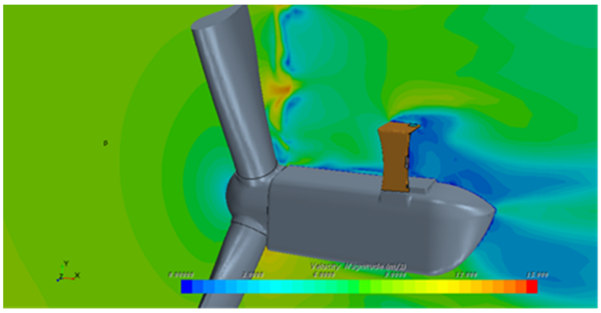

Fig. 1 Numerical simulation of the influence of impeller on anemometer

This technology uses numerical simulation modeling to calculate the influence of the wake on the anemometer. The input conditions include wind speed, wind direction, wind density, etc., and forms a matrix database to coordinate with the laser radar to call data.

Project scale and scheme:

Study on Quantifying Interference Factors of Anemometer and Wind Direction Meter by Numerical Simulation

It is impossible to accurately evaluate the status of the anemometer and wind direction indicator simply by comparing the Doppler lidar equipment with the anemometer and wind direction indicator. It is necessary to further clarify other interference factors, including the impact of impeller rotation under the operating state and the impact of impeller structure on the anemometer and wind direction indicator under the Y-type shutdown state, to analyze the initial yaw value of the wind direction indicator and optimize the unit operation.

The influence of the impeller on the anemometer can be calculated through numerical simulation. Taking the model building of 37.5m blade model as an example (Fig. 4), due to the interference of impeller, the wind speed data measured at the anemometer position in the engine room fluctuates periodically at 11m/s wind speed, as shown in Fig. 2, the anemometer results are always small, the detected value fluctuates between 8.5-10m/s, and there is 10-23% deviation from the incoming 11m/s wind speed.

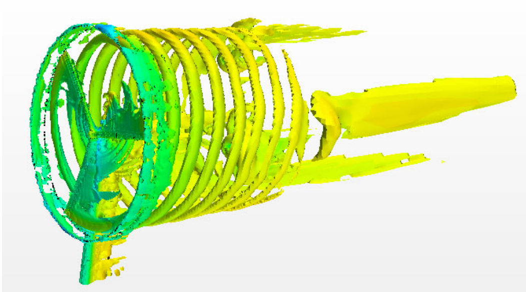

Fig. 2 Modeling of 37.5m blade model (contour map with vorticity=0.8)

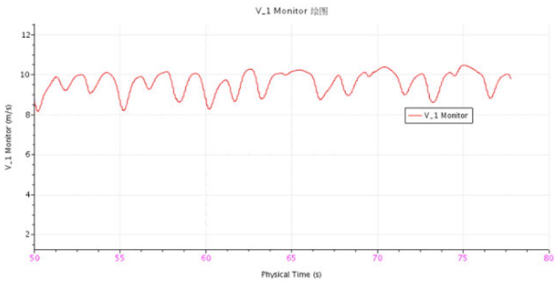

Fig. 3 Wind Speed Results of Existing Anemometers (11m/s)

As shown in Figure 3, when the theoretical wind vane should be at 0 °, it is interfered by the impeller, and the wind vane also has a certain angle deviation. Through big data analysis, it is usually interfered by the impeller, and the deviation of the wind vane is about 4 ° - 10 °.

The research content of this part belongs to theoretical calculation research, which is an important means to establish the impeller interference database through calculation, and 0 is an important reference basis for comparison between Doppler lidar measured data and wind speed and wind direction indicator.

Carry out research on the calibration method of Doppler lidar, focusing on the layout mode, scanning mode, dynamic screening process and static screening process of lidar; The corresponding software operating system is matched and developed. A screening method for the status of anemometers and wind direction indicators is developed for fans in operation; Develop the screening method of anemometer and wind direction indicator status under the Y-type shutdown status, and form a complete dynamic+static down wind speed and wind direction indicator status screening process.

Doppler lidar calibration technology is currently based on the International Electrotechnical Commission standard IEC61400-12-1 (2017). The equipment accessories used in this technology have been rigorously tested in Germany, and the measured data are compared with the data measured by the Class I wind cup anemometer in the international IEC standard. The correlation between them at any level is up to 99%, and the verification result is excellent. In this technology, the accuracy of numerical simulation wind speed can reach 0.05m/s, the accuracy of wind direction measurement can reach 0.1 °, the accuracy of lidar wind speed measurement can reach 0.1m/s, and the accuracy of wind direction measurement can reach 1 °, which fully meet the technical requirements of this project.

The calibration work will use the dynamic and static two-stage screening method to evaluate the two states of the fans in the wind farm:

In the first stage, dynamic screening: the Doppler lidar is arranged within the range of (0-50) meters on the ground at the front end of the wind direction of the wind turbine to measure the wind speed data at the installation height of the wind vane of the wind turbine; According to the wind speed data measured by Doppler lidar in real time, the correction coefficient of the wind vane of the wind turbine disturbed by the impeller under the non-stop state is called;

5. Conclusion

Compare the corrected wind speed data with the data measured by the wind vane of the wind turbine; Set the screening deviation limit, and enter the second stage when the deviation between the corrected wind speed data and the data measured by the wind vane of the wind turbine exceeds the screening deviation limit; When the deviation between the corrected wind speed data and the data measured by the wind vane of the wind turbine does not exceed the screening deviation limit, the recorded data deviation is used for the initial correction setting of the wind vane system; The laser radar is arranged at the nearest position at the front end of the fan to measure the wind speed and direction data at the installation height of the anemometer, and call the matrix database data to participate in the comparison according to the real-time wind changes. So far, the first phase of status screening has been completed.

The second stage, static screening: conduct shutdown test for wind turbines whose data deviation in the second stage exceeds the screening deviation limit. Shut down the fan blade in Y shape, place the Doppler lidar within (0-50) meters of the front ground in the wind direction of the wind turbine, and measure the wind speed data at the installation height of the wind vane of the wind turbine; According to the real-time wind speed data measured by Doppler lidar, the correction coefficient of the wind vane of the wind turbine disturbed by the impeller under the shutdown state is called; Compare the corrected wind speed data with the data measured by the wind vane of the wind turbine; Set the screening deviation limit. When the deviation between the corrected wind speed data and the data measured by the wind vane of the wind turbine exceeds the screening deviation limit, it is determined that the wind vane of the wind turbine under test is faulty and needs to be repaired or replaced.

The research content of this part is experimental research, which is an important research content of Doppler lidar application in wind speed and wind direction indicator status assessment, and an important technical means for verification of related methods.

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