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# Wind power cabin high temperature hot spot remote intelligent monitoring and early warning system

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### ABSTRACT

With the increasing energy crisis, the development and utilization of wind energy, which is a substitute for traditional energy sources and has renewable and cleanliness, has gradually attracted the attention of people all over the world. While the wind power industry is growing rapidly and the unit capacity of the unit is gradually increasing, the operational safety of wind power equipment is receiving more and more attention. If the wind turbine component fails, the small one will result in downtime maintenance, and the other will cause the machine to be destroyed. Because the wind farm is built in remote areas or offshore areas far away from the city, the traffic is inconvenient, and the wind turbines are at high altitude, so it is very difficult to maintain the unit. Once a fault or fire occurs, it is difficult to rescue in time. Let it develop its accident. In view of the high cost of detection, the failure of detecting faults, and the high proportion of missed faults, the on-line monitoring of the operating status of wind power equipment, the real-time diagnosis of early warning faults, and the maintenance of equipment are also important. The online monitoring system is applied to the health monitoring of wind power equipment, which not only can alert the equipment to potential failures, avoid the occurrence of major accidents, but also can determine the fault type and severity of the equipment based on the integration of existing analytical methods. Save on operational maintenance and repair costs. At a deeper level, mining and analyzing the monitoring data can also complete the estimation of the equipment's continuous running time before the major accident, promptly remind the staff and provide reasonable rescue plans and solutions.

**Keywords:** wind turbine; high temperature; Intelligent monitoring; Big Data; Early warning

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## Introduction

In the past ten years, China has created a miracle of wind power development. Hundreds of billions have been invested to build hundreds of wind farms and put into operation tens of thousands of typhoon power units. With the continuous extension of the operation time of wind power equipment, mechanical failure problems emerge one after another <sup>[1]</sup>. High temperature will occur in some parts of wind power room, which will lead to fire<sup>[2]</sup>. At the same time, areas with abundant wind resources are usually remote areas and at sea. In case of fan fire, it is difficult to realize timely rescue, which will completely destroy the whole wind turbine, causing great economic losses and social impact.

At present, there are two ways to monitor the state of wind motor equipment, and regular inspection and online state monitoring. Regular inspection requires the staff to climb onto the engine room with the testing equipment on their back according to the specified time for data collection. This method has low efficiency, great labor intensity of the staff, and is greatly affected by external factors such as weather. The collected information is delayed and has general effects. Of on-line monitoring system with modern scientific system theory, cybernetics, reliability theory and information theory as the theoretical basis, with materials, including sensor, information collecting, instrument equipment and computer, network, communication technology, some for on-line continuous monitoring of various operating parameters, make real-time evaluation to the equipment, the fault forecast and diagnosis in advance. At present, the emphasis is on the development of online monitoring and control of wind turbines<sup>[3]</sup>. For scattered wind turbines, it is

required to be able to operate unattended and monitor remotely, which also puts forward high requirements for the automation and reliability of the control system of wind turbines. As for the monitoring system of modern wind farms in China, the monitoring and data acquisition system developed by GoldWind technology, namely SCADA system, has the following main functions: Rapid data access, data relationship establishment and data historical playback have been widely used in traditional power generation industries such as thermal power and hydropower. In view of this trend, relying on the application and development of Internet, cloud computing, big data and other technologies, proposed to build an intelligent APP client terminal of remote intelligent monitoring and early warning system for high temperature hot spots in wind power engine room. Intended to can achieve real-time monitoring of running status of wind turbines, alarm and performance analysis, and other functions, through the 24-hour online monitoring of power equipment fever, timely grasp the hot wind motor operating temperature and the data, through the analysis of monitoring data, understand its running state, and the possible accident early warning, timely discover and eliminate the safety hidden trouble, no matter when and where to be able to make staff to receive alerts in time and take measures to avoid wind power cabin high temperature hot spots will have more serious consequences<sup>[4]</sup>, to enhance the operation safety and reliability of the wind turbine.

## System function

With the continuous development of computer technology and network communication technology, online monitoring of operating equipment has been continuously improved. The remote intelligent monitoring and early

warning system for high temperature hotspots of wind turbine cabins mainly includes temperature intelligent online monitoring and early warning system, equipment online monitoring system and remote intelligent control system. The system mainly involves three parts: data acquisition, calculation analysis and result display. When the system is put into use, the temperature information is collected by the sensor configured by the data acquisition layer, and then the data is uploaded to the central monitoring host server through the wireless network. The cloud platform performs data calculation and analysis. Finally, the processed information is displayed to the user through the mobile client, and the alarm information is sent when the danger occurs. When the high temperature occurs, the alarm is timely and the staff can realize real-time monitoring and take effective through the intelligent terminal Measures.

#### **Wind motor high temperature hot spot remote intelligent online monitoring system**

At present, monitoring the parts of the wind turbine cabin that are prone to high temperature hot spots, such as speeder oil temperature, high temperature bearing temperature, large generator temperature, small generator temperature, front and rear main bearing temperature, control panel temperature, controller ambient temperature<sup>[5]</sup>, etc. Part of the wireless temperature sensor (PT100) is used for temperature monitoring. Based on this, the advantages of fiber temperature sensor and infrared detection technology are combined to form a temperature intelligent online monitoring system for wireless sensor networks<sup>[6]</sup>, real-time temperature online monitoring, and monitoring data. Perform correct calibration and immediately generate an alarm signal for transmission when the temperature exceeds the

preset value.

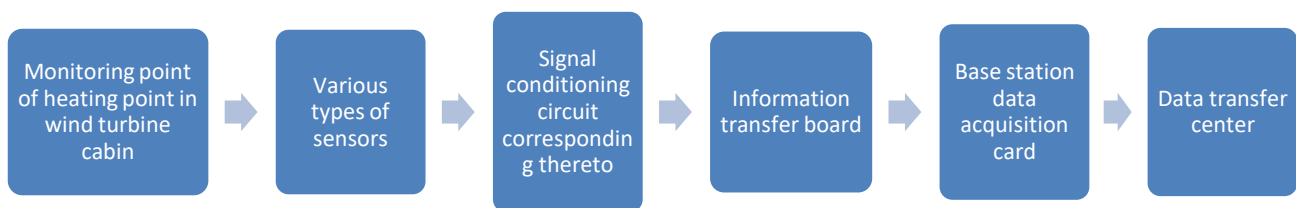
Features of wireless sensor networks:

- 1) Self-organizing network. Sensors form a self-organizing network through distributed network protocols, which can be automatically adjusted to accommodate node movement, join, and exit.
- 2) Reliable network. Sensor networks are particularly well-suited for deployment in specific areas where sensor nodes are often deployed in a random manner. The hardware and software of the sensor network must be robust and fault tolerant.
- 3) Dynamic network. The nodes in the wireless sensor network may exit from the network due to failure, or may exit from the network operation according to the set program; the wireless sensor nodes outside the network may join the network at any time; the sensor nodes have mobility.
- 4) The network is large. A large number of sensor nodes are typically deployed in the monitoring area to better capture accurate information.

The temperature intelligent online monitoring system uses radio waves for signal transmission. The sensor is installed on the monitored device and has no electrical connection with the receiving device. The sensor node transmits the collected data to the destination step by step through the corresponding signal circuit. After transmission, the data arrives at the data storage node, and the storage node sends the data collected by the sensor to the management node through the Internet. The system is equipped with standard communication interface, which can be operated in a network. Through the upper computer data storage system, it can record the real-time operating temperature data of the

equipment in the wind turbine cabin. By using ZigBee and GPRS network, the collected data is transmitted to the data relay center and the data is transmitted to the cloud platform. ZigBee is a low-cost, low-power, reliable and efficient short-range wireless networking communication technology. It operates in the 2.4GHz and 868/928MHz frequency bands and can resist various electromagnetic interferences in the

field and complete the data forwarding function in the network. The data monitored by the high-temperature hotspot intelligent online monitoring system is transmitted to the base station by wireless communication, and the base station and the data center are connected by RS485, RS232 interface or GSM network. The following figure shows the hardware design structure of the data acquisition system:



**Fig 1 Data acquisition system hardware design structure**

The data transfer center is mainly responsible for receiving acquisition commands from remote sensors. After the data is collected, the collected data is transmitted to the central monitoring server and the cloud platform<sup>[7]</sup>. The main components in this node are the GPRS module and the ZigBee module. GPRS universal wireless packet service is a wireless packet switching technology developed on the basis of the existing GSM system. It uses the unused TDMA channel in the GSM system to provide data transmission. It is actually another overlay on the existing GSM network. The internet GPRS supports TCP/IP protocol and can be directly interconnected with the Internet. Since GPRS is an upgrade of the existing GSM network, it can fully utilize the nationwide telecommunications network. Therefore, the GPRS network covers a wide range, and users can conveniently and quickly use the GPRS

service for remote network access anytime, anywhere. Once an abnormality occurs at a certain detection point, it immediately communicates with the remote server, and sends the abnormal data of the detection point to the remote server client, thereby completing the alarm function of the system and reducing the personnel duty time of the remote monitoring terminal.

#### **Central monitoring part of the host computer server and cloud platform module**

This module is mainly responsible for data analysis, diagnosis and storage functions. It transfers the data monitored by temperature sensor to server and cloud platform by means of wireless network. It centralizes the temperature measured by temperature measuring device downward, processes and transmits the measurement results upward, and plays a connecting role. With modern science and

technology is developing rapidly, but will become more and more mature expert system, neural network algorithm is integrated into the cloud background, with the monitoring data management software for data mining, data storage, data analysis and data alarm, can generate monthly operating temperature anomaly statistics, comprehensive statistics data trend curve display, and other functions. By comparing and diagnosing the new and historical data acquired constantly, the wind farm staff can be provided with real-time display and early warning of the temperature information of the equipment inside the station, so as to ensure the reliable operation of the equipment.

Cloud platform has a strong computing power and storage capacity of processing data, in a cloud platform built on the basis of the remote monitoring and data analysis center, to the remote real-time monitoring in individual wind turbines in the wind, on the one hand can fully grasp the operating temperature of the wind power equipment, timely processing high-temperature failure, ensure safe and reliable operation of the equipment; On the other hand, through the analysis and processing of a large amount of monitoring data, the development trend of temperature can be predicted and the causes of high temperature hot spots can be inferred to realize fault warning and determine the factors affecting the safe and reliable operation of equipment. In the event of a high temperature fault, a contingency plan is generated and a technical staff member is required to be present for repair. The main functions of the platform are:

#### 1) Standardized management

The temperature information collected by each

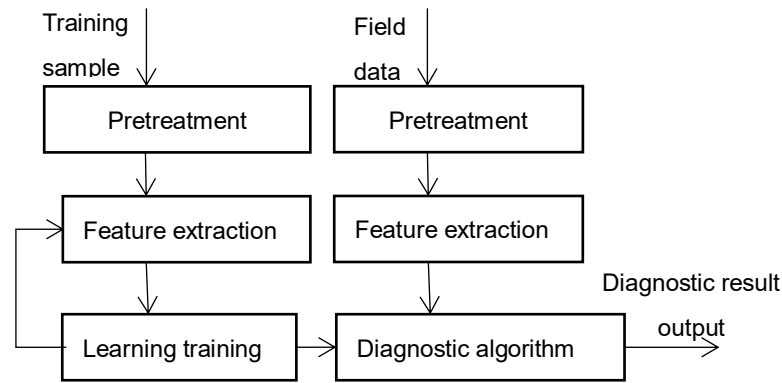
wind turbine in the wind farm is separately archived, and each small-database is formed according to the data report of each fan monitoring point, time period, fault type, early warning information, etc., and the data is stored and managed for operation. Provide convenient data for personnel query conditions, records, etc., and make full use of the powerful computing power and storage capacity of the cloud platform;

#### 2) Data processing

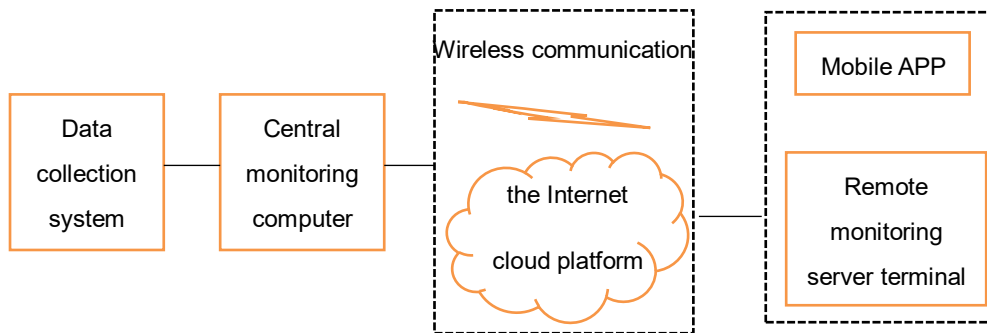
After the data collection in a certain period of time is completed, the correctness check is first performed in the data center. After the correctness verification is completed, the data is sent to the central monitoring and the cloud platform for storing and analyzing the data, and the wind motor can be operated in real time according to the historical data. The operating temperature condition of the monitored point is predicted; when the temperature exceeds the preset value, the cause of the hot spot is analyzed and the fault of the wind turbine may be predicted according to the specific part, the alarm level is given corresponding measures, and the auxiliary diagnostic solution is provided in combination with the algorithm diagnostic function . The following figure shows the data processing diagnostic structure diagram and the wind turbine remote monitoring system diagram in the cloud platform:

#### 3) The alarm is timely and the speed is fast

It is sensitive to the state of the temperature monitoring system object. Once an abnormal situation occurs, the SMS or client alarm push notification staff can be sent in real time, and the cause of the fault can be analyzed in time to generate an auxiliary solution to improve work efficiency and reduce work intensity.



**Fig2 data processing diagnostic structure**



**Fig 3 wind turbine remote monitoring system**

**Overall design of the system software**

The system is based on a remote intelligent temperature online monitoring system, which utilizes network communication technology, automatic control technology and big data for efficient integration. It is proposed that the design and development of mobile terminal remote intelligent control APP module is an important part of the system. The terminal program is developed based on Android and IOS operating system to adapt to the more popular mobile terminal devices on the market, and install the system to smart phones or IPAD<sup>[8]</sup>. Real-time remote control and data reading, and visual display; provide human-computer interaction, receive cloud background data processing results and display to the operator, and can also send operational commands to remote control of the wind turbine. The system mainly includes the following parts:

1) User login module

After the system is started, the user logs in to the system. The system can restrict the user's right to use and prevent unauthorized users from logging in to the system. The user must log in successfully before performing related operations. The relevant monitoring personnel and technical operators of the wind farm have their own designated account and authority login systems. They can also enter the system by setting fingerprint identification and face recognition, and the user's login information is stored in the database. This module guarantees the security of the system by restricting the user's software operations.

2) Network module

The network module of the APP software system adopts the Wi-Fi or GPRS wireless connection mode, and the APP terminal communicates with the data concentrator, the remote monitoring terminal, and the cloud platform through the network wireless

connection, and the status data transmission and interaction from the device in real time. The module manages and configures network connections, scans access points, and monitors network signal strength changes.

### 3) Setting the module

The module is mainly used for data display and setting. The temperature data of the monitored point is read in real time through the connection with the cloud platform and the data center; a temperature upper limit alarm value can be preset in the module for the specific part, and the Celsius can be performed. The conversion between temperature and Fahrenheit can be performed; and the addition of data, that is, the data of the newly added device temperature monitoring point, can be set.

### 4) Monitoring system

The system monitors the running state of the wind turbine cabin in real time, realizes the screen display of the wind turbine control operation, displays the monitoring point temperature in real time in the terminal, and can query the real-time data of each monitoring point in a graphical operation manner; once the temperature value is measured at the scene Exceeding the set temperature limit, the monitoring system will promptly send out an alarm signal or send a text message reminder to the mobile phone. In order to ensure that the operator can find the problem in time and make timely control and troubleshooting of the wind turbine failure, the system provides a first-level alarm and two. The level alarm setting is different for the alarm sounds and sounds issued by different alarm signals, and the historical data can be used to query the cause of the fault; the monitoring system realizes the automatic control of the unit power-off protection in time when the unit temperature is

too high.

### 5) Equipment warning and control functions

The equipment early warning management is mainly to manage the temperature warning threshold of the temperature measuring device, and can perform combined equipment early warning, such as temperature value and temperature variation speed combined to carry out equipment temperature warning, which can promptly remind and generate high temperature push in the initial stage of equipment temperature change. And give the overload safe running time under the current environment and load level. Once the alarm signal is received, it is found that the signal is out of the normal range for a certain period of time. In order to prevent the occurrence of the fault, the corresponding protective measures must be taken immediately. If the operation alarm signal is not processed in time, it is easy to delay the optimal timing. In order to prevent major losses, the monitoring system automatically issues an interrupt command in time, and the control function issues a stop device command; in addition, a remote start device, a reset device, and a calibration device are also provided. Minimize maintenance of wind farm systems.

### 6) Data analysis function

Combined with the data processing of the cloud platform, the APP mobile terminal occupies less storage resources, so that the mobile phone runs smoothly and easily obtains a better user experience. The module can query and analyze statistical data in various aspects; customize historical data, real-time data reports and temperature change trend maps according to requirements, and can perform operation records, fault records and event log queries. On this basis, an alarm record interface is formed, and the alarm threshold and history record are

saved for the alarm threshold set by the user in the channel configuration interface; the alarm record history column can be in the form of a table, and each alarm event of the channel is displayed in real time. Alarm time and alarm value; combined with historical records and algorithms in the cloud platform can form a device temperature prediction model, based on the temperature monitored in real time, can predict the temperature trend of the monitored part; and provide time analysis, classification analysis, performance analysis, The public opinion prediction and optimization suggestions enable the operator to better monitor the wind turbine.

### **Characteristics of remote intelligent detection and early warning system for high temperature hotspots in wind turbine cabin**

1)The temperature monitoring of the system uses a wireless sensor network intelligent temperature acquisition scheme with the following features:

- ①The network monitors and manages the sensor to wirelessly transmit temperature information;
- ②Wide operating temperature range, free from high temperature, high voltage, strong electromagnetic field environment, high reliability;
- ③real-time online, high temperature measurement accuracy, visual display of sensor data;
- ④send commands and transmit signals;
- ⑤long working life, almost maintenance-free.

2)The monitoring system described in this system can well realize the monitoring of remote scattered multi-point monitoring points, not affected by environment, distance and other factors, not only saves the cost of remote monitoring; It also saves human resources, not

having people on duty all the time; At the same time, it also solves the real-time feature of decentralized multi-point monitoring and maintains the real-time communication with the terminal, so as to make the data of each terminal consistent with the base station.

3) The system through the sensor network to collect data, based on the cloud platform strong computing power and storage capacity to analyze data computing and storage, do not take up mobile computing resources and storage space, reduces the computing and storage of APP terminal load, giving users ran smoothly to avoid using mobile phones too much space to cause blocked to have a good experience. With the storage function of cloud platform, the same APP can adapt to a variety of intelligent terminals. When the operator has access to the login management authority, it can read and export the data in real time, control the temperature change trend, and facilitate data sharing and data analysis between tools of different platforms.

4) This system can realize automatic monitoring and early warning of hot spots of high temperature of wind motor without manual intervention. It adopts modular design, including network controller module, server system and APP software system. The mapping relationship to the monitoring points is realized and the two-way data and command channels are established. When hot spots occur, the mobile terminal shall send SMS or alarm sound to remind the mobile terminal, so that the staff can control the operation status of the wind motor at anytime and anywhere, and provide auxiliary treatment schemes, and take measures in time; Online remote control can be adopted for the impact of hot spots, and when the problem cannot be solved, technicians can be arranged for inspection, saving labor costs.



5) The system is connected to the wireless network, with intelligent sensors as the front end, collecting hot temperature data, providing human-computer interaction with APP as the media, and providing data mining, analysis, storage and sharing with the powerful computing power of cloud platform as the back end. Based on cloud platform can collect data of big data analysis, wind power to operate large data analysis and processing technology is a new technology in the field of domestic wind power development trend, through the analysis of the large data processing can provide more comprehensive and accurate technical information for wind power enterprises, grasp equipment performance and operation characteristics, to find the equipment design and manufacturing defects, improve the quality of the product design process and the reliability, reduce wind turbines equipment failure rate and failure of maintenance downtime, improve the safe and economical operation of wind farms.

### Conclusion and outlook

The remote intelligent monitoring and early warning system for high-temperature hotspots in wind turbines can remotely monitor high-temperature dangerous points in the engine room. Once a fault occurs, it can be quickly and quickly reported to the staff and promptly and automatically solved. It can be established on the SCADA-based system, or it can add other sensors to increase the function of the whole system, such as temperature and humidity in the cabin, equipment vibration, etc., and strengthen the reliability of the automatic analysis algorithm and ensure the wireless network can work effective delivery. Through the system, timely and effective monitoring and control of high temperature fault points in the engine room can not only reduce the damage and loss of wind turbines, but also prolong the

service life of wind turbines and continuously generate green energy.

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