Research on Intelligent Monitoring Technology of Substation and Distribution Station Driven by Big Data

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Abstract. The power transformation and distribution station is the power supply foundation to ensure the normal operation of all kinds of large factories and large communities. The realization of the overall solution of intelligent monitoring system for transformer and distribution station based on big data helps to ensure the safe operation of power transformation and distribution station and ensure the quality and stability of regional power supply. The intelligent monitoring system of power transformation and distribution station based on big data is composed of automatic monitoring system of power transformation and distribution station and intelligent monitoring system of Internet of things of power transformation and distribution station. Through the research and application of partial discharge monitoring, SF6 leakage detection, wireless sensor and other technologies, big data analysis technology is used to analyze the monitoring data, so as to realize remote monitoring and intelligent monitoring and diagnosis of power transformation and distribution station.

Keywords: Power transformation and distribution station, intelligent monitoring, sensor, Internet of things

1. Introduction

With the vigorous development of big data and Internet of things technology, the intelligent monitoring technology of power system has been widely studied, and the intelligent monitoring system of power transformation and distribution station based on big data drive has become a trend [1-2]. In modern power transformation and distribution stations, a large number of temperature, humidity, smoke sensing, vibration, water immersion, door magnetic induction and other sensor types are widely used. Through these sensors, sound, heat, force, light, electricity, displacement and other signals can be sensed, and accurate analysis and decision-making can be made based on these information [3]. By using the Internet of things and big data analysis technology, in the computer simulation environment, the equipment operation in the whole substation is displayed digitally, operated automatically and analyzed intelligently [4-6]. In China, the transformation and distribution and intelligent technology has been unprecedented rapid development, the traditional and backward substation is being replaced by modern substation.
2. Basic situation of power transformation and distribution station

For the former substation technology transformation and for the new substation using advanced technology, we can improve the automation level of substation, gradually realize intelligent monitoring. Taking the 35kV substation as an example, the main equipment includes two 35kV/6kV transformers, which is two-way power supply mode, several sets of high-voltage switch cabinet, and electric energy meter and other instruments. The switchgear adopts high-performance gas insulated switchgear. The complete set of switchgear has reliable power transmission, digital protection and control technology, intelligent sensor system and convenient plug-in connection. The multifunctional integrated protection switch control device applied to the switch cabinet is an important communication interface to realize the integrated automation system of the substation. The switch device integrates the functions of protection, control, measurement, monitoring, self diagnosis and communication, and is used for automatic distribution network.

3. Function and realization of automatic monitoring system for transformer and distribution station

Through the PLC control system, relying on various kinds of communication to read the data of the electrical switch cabinet, and with the computer configuration software, the remote monitoring of the operation of the transformer and the switch cabinet can be realized [7-8].

The functions of power supply and distribution monitoring system in substation mainly include data acquisition and processing, control operation, alarm and processing, telecontrol, synchronous clock, man-machine joint and operation management these seven functions, including data acquisition and processing function, control operation function, alarm and processing function, remote control function, synchronous clock function, man-machine joint function and operation management function.

Combined with the situation in China, the substation intelligent monitoring system should realize the following five changes: the monitoring system should replace the conventional measurement system; replace the pointer type instrument; change the conventional operating mechanism and analog panel; replace the conventional alarm, central signal, optical signboard and so on; replace the conventional remote control device.

In the automatic monitoring system of the substation, PLC is connected with the integrated protection device through the communication protocol to read the data of voltage, current, frequency, power factor and power. The automatic monitoring system of the substation is realized by configuration software. It is mainly composed of the primary system diagram of the power transformation and distribution system, the status of each switch and monitoring data, so as to realize the collection, display and processing Basic functions, as well as other important functions such as data judgment, trigger alarm, alarm record, operation guidance and so on[10-11]. The structure of substation operation and maintenance management system is shown in Fig. 1.
4. Intelligent monitoring system of Internet of things in substation

The application of Internet of things technology to realize intelligent monitoring and diagnosis of transformer substation can be divided into three parts: the partial discharge monitoring system, wireless sensor monitoring of cable temperature and bus temperature, and video monitoring of transformer oil tank and cable joint for 35kV/6kV transformer; the temperature and humidity inside the switch cabinet, cable joint temperature, cabinet door switch signal wireless sensor monitoring, as well as SF₆ leakage detection under the cabinet for the switch cabinet; the environmental monitoring, the temperature and humidity and smoke alarm monitoring of each room, and the water immersion monitoring of the underground layer of the substation for the whole substation.

4.1. Application of Internet of things technology in substation

In the overall solution of intelligent monitoring of power transformation and distribution stations, technologies such as partial discharge monitoring, SF₆ leakage detection, wireless sensor and wireless photoelectric smoke detector are mainly used [12].

4.1.1. Partial discharge monitoring. When the internal performance of transformer is poor or fault occurs, it will form partial discharge and heating and other physical characteristics. Partial discharge monitoring is taken as the main detection method to carry out regular intelligent inspection on insulation basin, and early warning and warning functions are mentioned. Two 35kV/6kV transformers in the substation and distribution station of the raw water pump station are equipped with partial discharge online monitoring system. The partial discharge signals of UHF (ultra-high frequency, 300~3000MHz) are collected and transmitted to the host through coaxial cable. The discharge signals are analyzed and processed, and the partial discharge signals are reliably judged. When the partial discharge monitoring system monitors the partial discharge signal, the two-dimensional and three-dimensional patterns of the discharge signal can be inquired through the software. The two-dimensional map can directly display the discharge amount, and the three-dimensional map can judge the discharge type. According to the monitored discharge position, the insulation status in the operation of transformer can be found...
effectively, the defects of insulation manufacturing process and the errors in the installation process can be found, and the hidden trouble can be handled in time to ensure the safe operation of the equipment.

4.1.2. $\text{SF}_6$ leakage detection. The core sensing elements of $\text{SF}_6$ leakage detection are $\text{SF}_6$ sensor and oxygen sensor, which are composed of high-performance embedded microcontroller and amplifier[13]. According to the characteristics and leakage characteristics of the gas, $\text{SF}_6$ and oxygen monitoring units are installed under the $\text{SF}_6$ switch about 10cm from the ground. The host computer transmits the real-time data to the computer in the control room through the network for dynamic monitoring. When the $\text{SF}_6$ gas leakage is detected, the system automatically turns on the fan for exhaust, and has 10m long-distance human body infrared detection, voice prompt and high-frequency flute sound alarm, light alarm, timing or overrun trigger or forced fan start/stop operation and so on. The schematic diagram of $\text{SF}_6$ gas leakage alarm system is shown in Fig. 2.

**Fig.2 Schematic diagram of SF6 alarm system**

4.1.3. Wireless sensor system. It consists of various types of wireless sensors, networks, and wireless sensor base stations. According to the type of sensors, various types of data can be monitored, including temperature, humidity, door magnetism, water immersion and photoelectric smoke detector.

4.1.4. Wireless temperature sensor
It is composed of temperature sensing module, digital to analog conversion module, wireless radio frequency transmission module and power supply module, and is packaged by miniaturization. The principle of temperature measurement is thermistor temperature measurement. The resistance value of thermistor will change with the change of temperature. The temperature can be reflected by the resistance value, and the sensitivity is high. It can be used for real-time on-line monitoring to realize the temperature of power equipment, and realize the intelligent analysis of temperature rise and temperature
difference according to the monitoring data, so as to provide scientific basis for analyzing and warning the operation stability of the equipment. Wireless temperature sensor is used in transformer, cable joint, knife contact, copper bar connection point, capacitor, arc suppression coil, shell of easy heating equipment and so on.

4.1.4.1 Wireless temperature and humidity sensor
Wireless temperature and humidity sensor is composed of thermistor, polymer humidity sensitive resistor, digital to analog conversion, wireless radio frequency transmission and power supply. The core of the work is thermistor and polymer humidity sensitive resistor, which can accurately measure the temperature and humidity in the environment. It can be installed in high-voltage electrical cabinet, switch cabinet, pump room, power transformation and distribution station, and it can also be installed in places easy to heat and humidity.

4.1.4.2 Wireless door magnetic sensor
Through the door magnetic sensor installed on the cabinet door, magnetic field can be formed with permanent magnet or electromagnetic coil to monitor the opening and closing state of the cabinet door, and count the opening and closing times. When the cabinet door is not closed after being opened by the operator, the system will automatically remind; when the cabinet door is opened illegally, the system will automatically alarm.

4.1.4.3 Wireless water immersion sensor
It is used to monitor whether the sensor installation position is flooded, and upload the flooding signal to the control host through the transmission base station in real time, so as to achieve the purpose of online monitoring and alarm. The water immersion sensor sends wireless signals at the interval of 60s. When it changes its state, it will send three wireless signals at the interval of 6s.

4.1.4.4 Wireless photoelectric smoke detector
When smoke is generated in a room, the sensor detects the smoke signal and the system sends out an alarm. The wireless photoelectric smoke detector can give an alarm by detecting the smog generated by the smoldering of combustor to avoid more serious fire.

4.2. Realization of Internet of things intelligent monitoring system in substation.
The Internet of things monitoring system of power transformation and distribution station mainly consists of equipment condition monitoring and intelligent alarm, and environmental monitoring and auxiliary control.

4.2.1. Equipment condition monitoring and intelligent alarm. Wireless temperature sensors are installed at cable joints, power bus bars, switch cabinet cable joints, cable wells, motor wiring and other heating equipment. In the switch cabinet, install temperature and humidity, door magnetic induction. The IOT (Internet of things) system can real-time monitor the temperature, temperature and humidity of the equipment and the status of the switch cabinet door, and set the alarm threshold value for the temperature, so as to avoid the fault and loss caused by the high temperature.

4.2.2. Environmental monitoring and auxiliary control. Wireless temperature and humidity sensors and smoke detectors are installed in each room of the substation to realize the monitoring and alarm of indoor temperature, humidity, smoke and other environmental changes, and it also links with air conditioning, fans and other equipment. Wireless water immersion sensor is installed in the underground water collecting well of power transformation and distribution station to monitor the water level in real time and link with the water pump in the water collecting well.
5. Application of big data analysis

Big data analysis is one of the core technologies to realize intelligent monitoring system of power transformation and distribution station[14]. According to the accumulated experience of power transformation and distribution equipment operation and personnel management, data monitored by automation system and Internet of things monitoring system and scientific model, an intelligent processing method is established to effectively and scientifically achieve the goal of big data analysis. Different from the traditional on-line analytical processing (OLAP), the deep analysis of big data is mainly based on large-scale machine learning technology. Generally speaking, the training process of machine learning model can be summed up as the optimization of the objective function defined on the large-scale training data, and is realized by a cyclic iterative algorithm. Therefore, compared with the traditional online analytical processing, big data analysis based on machine learning has its own unique characteristics.

1) Iterative. Since there is usually no closed form solution for optimization problems, it is not possible to determine the parameters of the model at one time, and it is necessary to iterate repeatedly to approach the optimal value point step by step.

2) Fault tolerance. The algorithm design and model evaluation of machine learning can tolerate the existence of non optimal points. At the same time, the characteristics of multiple iterations also allow some errors in the process of the cycle, and the final convergence of the model is not affected.

3) Non uniformity of parameter convergence. Some parameters in the model will not change after a few rounds of iteration, while some parameters will take a long time to achieve convergence. These characteristics determine that the design of an ideal big data analysis system is quite different from that of other computing systems, so as to avoid the waste of resources in inefficient computing such as communication, waiting and coordination. The application of big data analysis technology in intelligent monitoring system of power transformation and distribution station will contribute to the realization of "Smart Substation".

To sum up, the application of big data technology is mainly reflected in four key points:

a. All devices should have network connection in order to obtain data and enrich data;

b. There should be various types of Internet of things sensors, data diversity;

c. Big data acquisition, after connecting all devices and people, all data will be massively concentrated into the intelligent information system, and the algorithm of big data analysis will be optimized;

d. Analysis and decision-making, after obtaining a large number of data, it is necessary to analyze, get more scientific and accurate operation trend, and put forward decision-making opinions on the detection and prediction of equipment status.

6. Summary

With the continuous development and progress of science and technology, big data analysis and Internet of things technology is becoming more and more mature, which provides a strong support for the management of modern substation intelligent monitoring system. In the future, by installing intelligent control unit in power transformation and distribution equipment, the equipment can be endowed with certain wisdom or thinking ability, and then realize human-computer interaction. The organic combination of technological innovation and management innovation, the overall solution system of intelligent monitoring of 35kV substation based on big data is constantly complete, which has certain promotion value in various types of substation and distribution station, and is the development trend of intelligent management of substation.

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