Design of Liquid Level and Generator Temperature Display System for EDG in Nuclear Power Station

Yong Zhou¹, Pengshu Zhu¹ and Xincai Chang²,*

¹Daya Bay Nuclear Power Operations And Management Co.,Ltd, Shenzhen, China
²China Nuclear Power Technology Research Institute, Beijing, China

*Corresponding author e-mail: changxincai@cgnpc.com.cn

Abstract. At present, EDG used in nuclear power plants is relatively old. The main means of EDG condition monitoring is the on-site dashboard installed in the EDG factory, which shows the relevant thermal parameters of operation. The instrumentation equipped in the factory can only display the current value of the liquid level of the diesel engine and the temperature of the stator coil of the generator. It cannot view the historical data and has no function of data storage and transmission. At present, manual recording is carried out by means of periodic inspection, which cannot fully reflect the operation status of diesel engine, capture transient process and time series change process, and evaluate the health value of equipment. Moreover, the existing monitoring methods cannot detect abnormal conditions in advance before the serious failure of EDG. In this paper, the modification of the existing on-site instrument of EDG is discussed, and the intelligent display function of on-site liquid level and generator coil temperature is added, so that the device can be applied to the complex EDG working site.

1. Introduction

The power failure accident of the whole plant brings harm to the normal operation of the nuclear power plant. For this reason, when designing the nuclear power plant, emergency diesel generator set is set up to deal with the power failure accident of the whole plant. At present, the main means of diesel engine condition monitoring is the on-site dashboard installed in the diesel engine factory, which shows the relevant thermal parameters of the operation.

At present, the EDG of nuclear power plant is relatively old. The local liquid level and generator coil temperature display instrument can only display the current value, cannot view historical data, and does not have the function of data storage and transmission. At present, manual recording is carried out by periodic inspection [1], which cannot fully reflect the operation status of diesel engine, capture the transient process and time series change process, and evaluate the health value of equipment, which is the main characterization of equipment performance [2]. The existing monitoring methods fail to detect abnormal conditions in advance before serious faults occur in diesel engines.

In order to solve the above problems, the existing local instruments of diesel engine are reformed [3]. It includes replacing temperature display instrument of generator coil, increasing data storage, display and analysis system, etc. The device is applied in complex field.
2. System Overall Design
The overall design of the liquid level and generator temperature display system for EDG in nuclear power plant is shown in Figure 1. The liquid level signal and generator temperature signal related to EDG are collected by the data acquisition cabinet and stored in the data server. Field personnel can view real-time status and historical data through IPC.

3. Design of acquisition system

3.1. Design of Liquid level and temperature acquisition system
A monitoring cabinet is designed to display the local liquid level and generator temperature.

The liquid level display used in the monitoring cabinet is shown in Figure 2 below. The instrument is equipped with a current output interface, which can transmit the measured sensor data to the rear instrument through the current output port. The sensor input terminal of the liquid level display receives the signal from the sensor and outputs it to the acquisition device through the current output terminal. At the same time, the current acquisition value of the sensor is displayed on the panel of the liquid level display.

3.2. Design of data server
A data server is configured in the condition monitoring cabinet to realize data storage, data analysis and data processing. It supports Oracle, SQL Server, DB2, MySQL and other mainstream databases.
4. Software design
The system software mainly consists of client software and server software. The client software is responsible for human-computer interaction. It mainly realizes the functions of real-time data monitoring, alarm and switch change query, curve playback and test data query. Server-side software is mainly responsible for data transmission and processing, real-time data processing, alarm analysis, data communication, data storage and other functions.

4.1. Design of Client Software
The client software runs in Windows environment. As the man-machine interface of the system, the user can input instructions and obtain information through the program. The system consists of three menus: monitoring module, list and data analysis. The monitoring module interface of client software is shown in Figure 3.

![Figure 3. Diagram of client software interface](image)

When the system works, the data collected by the lower computer is transmitted to the client in real time through the data processing module, and the client displays the corresponding measuring point information according to the menu currently selected.

The main data analysis interface is shown in Figure 4. Mainly includes: formula quick selection, time shortcut button, header, graphics area, test point search. Display the real-time trend and historical trend of multiple curves.

![Figure 4. Data Analysis Interface Design](image)

4.2. Design of Server Software
The main function of server-side software is responsible for data transmission and processing. Data transmission refers to the collection of field data through various protocols to achieve real-time data transmission, analysis and processing, preservation, alarm analysis and other functions. The original
The data communication protocols include Modbus-RTU, Modbus-TCP and ssh. The storage tools involved include Redis, Kafka and MongoDB.

The software has such algorithms as cumulative threshold algorithm, cumulative year-to-year algorithm, classification algorithm, clustering algorithm and statistical analysis method. With these algorithms, field personnel can obtain the health status of diesel generating units by analyzing historical data and real-time data.

5. Main Performance Tests

5.1. Sensitivity test

Verify that the temperature signal of diesel engine generator can be collected by the acquisition system and displayed accurately in the client interface. According to K-type thermocouple indexing meter, when the temperature is 100°C, the corresponding thermoelectric potential is 4.095 mV. The process calibrator FLUKE753 can be used to simulate the temperature signal source and output mV-level signal. The corresponding channel values are displayed and recorded by the host computer software. The error of the measured values is verified to be less than 1% of the set value.

| Verified signal | Testing activities | Test channel terminal | Settings (mV) | reference value(°C) | measured value(°C) | Results |
|-----------------|--------------------|-----------------------|---------------|---------------------|-------------------|---------|
| Generator stator coil temperature 913MT | FLUKE753 analog output 4.095 mV, verify that the measurement error is not more than 1% of the actual set value. | Red test pen connect terminal 1 (+) Black test pen connect terminal 2 (-) | 4.095 | 100±1 | 100.1 | ■ Qualified □ Unqualified |
| Generator stator coil temperature 914MT | FLUKE753 analog output 4.095 mV, verify that the measurement error is not more than 1% of the actual set value. | Red test pen connect terminal 3 (+) Black test pen connect terminal 4 (-) | 4.095 | 100±1 | 100.2 | ■ Qualified □ Unqualified |
| Generator stator coil temperature 915MT | FLUKE753 analog output 4.095 mV, verify that the measurement error is not more than 1% of the actual set value. | Red test pen connect terminal 5 (+) Black test pen connect terminal 6 (-) | 4.095 | 100±1 | 100.2 | ■ Qualified □ Unqualified |

The test results in Table 1 show that the state monitoring system can measure mV level signals and the measured values are within the reference range, and the sensitivity of the system meets the design requirements.

5.2. Stability test

In order to verify the stability of the system, two tests were carried out on the monitoring system, namely short-term stability test (continuous operation for 8 hours) and long-term stability test (continuous operation for no less than 1 week). Set test parameters, room temperature 25 degrees Celsius, humidity 50%, start the test. During the testing process, the given liquid level signal and generator temperature signal are tested repeatedly, the measured values of each given signal are recorded, and the historical trend curve of the client software is checked to verify the stability. After the test, the consistency of the collected data is good, and the verification results meet the stability requirements. The system runs for a long time.

6. Conclusion

In this paper, a monitoring cabinet is designed to display the local liquid level and generator temperature of emergency diesel engine. The system establishes a historical and real-time database for the start-up and operation process of emergency diesel engine group, provides a whole process monitoring and service system for the operation and maintenance of diesel engine, and provides support for the operation, management and maintenance of emergency diesel engine.
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