Research on early warning method of coil temperature of emergency diesel generator set in nuclear power station

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Abstract. As the last back-up supply of the nuclear power supply system, it is of great significance to ensure the safety and reliability of the nuclear emergency diesel power unit. For the emergency diesel generator set of nuclear power plant, the various signal types of diesel generator set are quasi periodic non-stationary signals, which make the diesel generator set have the characteristics of complex fault mechanism, difficult to collect and process all kinds of signals in a unified way, and difficult to extract fault features. The main purpose of this paper is to provide an early warning method and system for the coil temperature of diesel generator set in nuclear power station. By building a synchronous collection system for the coil temperature of diesel generator set, the collected coil temperature is counted in real time, and the abnormal analysis is carried out according to the real-time predicted value, and the early warning is carried out in time in case of any abnormality, so as to ensure the normal operation of diesel generator set.

1. Introduction

At present, the emergency diesel engine of the nuclear power plant in operation is relatively old. The coil temperature display instrument of the generator set in the diesel engine unit can only display the current value, cannot store data, and cannot view the trend of temperature change, which is not conducive to judge the health of the diesel engine [1-2]. In addition, at present, it cannot adapt to the complex operating conditions of diesel engine, capture the transient process and time sequence change process, only by means of regular patrol inspection, artificial setting of temperature warning threshold and manual recording of data, so it is unable to evaluate the health value of equipment and make timely warning, which is easy to cause the failure of diesel generator set and the failure of timely maintenance.

For the emergency diesel generator set of nuclear power plant, the various signal types of diesel generator set are quasi periodic non-stationary signals [3], which make the diesel generator set have the characteristics of complex fault mechanism, difficult to collect and process all kinds of signals in a unified way, and difficult to extract fault features. Through the real-time statistics of the coil temperature value, the real-time predicted the value of the coil temperature which is calculated according to the collected temperature related parameter data, and then the difference between the predicted value and the actual value is used for the abnormal analysis. And in case of any abnormality, an early warning is given in time, so as to ensure the normal operation of the diesel generator set [4].
2. System Overall Design

As shown in Figure 1, the coil temperature early warning system of diesel generator set in nuclear power plant includes:

Data acquisition module [5], which is used to collect the actual temperature value of the generator coil and the temperature related parameter data;

The communication module, which is used to realize the data communication among the modules of the system;

Early warning module, which is used to compare the actual temperature value of the collected generator coil and the temperature related parameter data with the corresponding set threshold value. If the range of the set threshold is exceeded, the alert information of the corresponding parameter will be given. If the range of the set threshold value is not exceeded, the temperature related parameter data is input into the temperature prediction model to calculate the real-time predicted value of the coil temperature of the generator set, and the actual temperature value is compared with the real-time predicted value. When the difference between the two values exceeds the range of the set threshold value, the early warning information is given [6];

Storage module is used to store the data collected by the data module, the data calculated by the early warning module and the early warning information;

Display module is used to display the collected data, real-time forecast value and early warning information.

Figure 1. Schematic diagram of coil temperature early warning system of diesel generator set in nuclear power station
3. Early warning method

![Flow chart of coil temperature early warning method for EDGs in nuclear power station](image)

**Figure 2.** Flow chart of coil temperature early warning method for EDGs in nuclear power station

As shown in Figure 2, the coil temperature early warning method of diesel generator set in nuclear power plant includes the following steps:

1. Collect the actual temperature value of the generator coil and the parameter data related to the temperature;

   In this step, the actual temperature value of the generator coil and the temperature related parameter data are collected periodically, and the collection period can be set according to the actual situation;

   In practical application, the temperature related parameter data can include the data that the power, voltage, current and ambient temperature of the generator set are directly or indirectly related to the coil temperature of the generator set;

   In this step, the actual temperature value and temperature related parameter data of the above collected generator coil can be compared with the corresponding set threshold value at first. This comparison process is a preliminary detection step, which is used to early warn obvious abnormal information. The range of the set threshold of the coil temperature and related parameters is the maximum range that can be reached under normal working conditions. When any collected parameter value exceeds the range of the set threshold, an early warning of the corresponding parameter will be carried out and the process of this early warning method will be ended. Otherwise, the next step will be carried out.
(2) Input the temperature related parameter data into the temperature prediction model, and calculate the real-time prediction value of the generator coil temperature;

Firstly, the temperature prediction model is established

1) The historical data of generator coil temperature and temperature related parameters are obtained from the database;

2) Clean the historical data of the coil temperature and temperature related parameters of the generator set, synchronously remove or replace the invalid data according to the time stamp, and eliminate the inconsistency between the data;

It is worth noting that there are some invalid data in the historical data of many parameters collected from the database. Therefore, before using these data, it is necessary to clean the obvious invalid data, which can be eliminated or replaced;

When the invalid data is eliminated, in order to ensure the alignment of the time stamps of all parameters, other parameter data corresponding to the time stamps need to be eliminated synchronously. When only one or two parameters of the data corresponding to the time stamp are invalid, the replacement method can also be used, that is, combining with the operation state of the generator unit, extracting data features from similar operation states in other cycles, data migration, and ensuring that the transplanted data is controlled within the theoretical range to ensure the accuracy of the data.

3) Using clustering algorithm to classify the running state of the historical data, and aligning according to the time stamp;

For example, the diesel engine is usually divided into hot standby state, operation state and cooling state according to the operation conditions and the operation state are also divided into load and no-load, which are reflected in the collected parameter data, such as speed, active power and reactive power. In this embodiment, the historical data of multiple parameters can be divided into three categories by clustering algorithm: operation work, operation no-load and non-operation status. For each category of status, the prediction model of the temperature of the coil under each category of status needs to be established.

4) The correlation coefficient between each parameter and coil temperature is obtained by analysing the historical data of parameters and coil temperature after classification;

Because the influence weight of each parameter on the coil temperature is different, it is necessary to analyse the correlation between the historical data of each parameter and the corresponding coil temperature data to get the correlation coefficient between each parameter and the coil temperature.

5) Taking the operation state as the modelling direction, the temperature prediction model is established by using the historical data and the correlation coefficient between each parameter and the coil temperature.

According to the above classified States, the historical data of multiple parameters in each state are sorted by time stamps, and the time stamps of multiple parameters are the same. At this time, the historical data of time stamps alignment and the correlation coefficient between each parameter and the coil temperature calculated above are used to establish the prediction model of the above parameters on the coil temperature by using the neural network algorithm;

The real-time prediction value of the coil temperature can be obtained by introducing the parameter data related to the coil temperature collected above into the temperature prediction model.

(3) Compare the actual temperature values with the real-time predicted value, and judge whether early warning is needed according to the difference between them;

(4) When the difference values exceed the set threshold range, an early warning message will be given;

In this step, the threshold range of the difference between the actual temperature and the real-time predicted value can be determined by the coil temperature and the historical data of the parameters related to the coil temperature, specifically:

The temperature prediction model is used to back calculate the historical data of the parameters related to the temperature, and the prediction data of the historical data of the corresponding coil temperature is obtained;
The difference between the coil temperature history data and the corresponding prediction data is calculated, and the Gaussian distribution processing is performed to obtain the mean value and standard deviation of the difference. The threshold range of the difference can be determined by using the mean value and standard deviation, and the range of the standard deviation can be set according to the actual situation.

5) Depth optimization of the temperature prediction model

In this step, the actual temperature value of the generator set coil collected each time and the temperature related parameter data are introduced into the temperature prediction model as data samples, so as to continuously modify and deeply optimize the temperature prediction model, so as to make it more consistent with the operating conditions of the diesel generator set. In order to accurately detect the abnormal condition of the coil temperature and relevant parameters of the diesel generator set.

4. Conclusion

This paper presents a method and system of early warning for the coil temperature of the emergency diesel generator set in nuclear power station. The method includes the following steps: collecting the actual temperature value of the coil of generator set and the parameter data related to the temperature. Input the above temperature related parameter data into the temperature prediction model to calculate the real-time prediction value of the coil temperature of the generator set. Compare the actual temperature value with the real-time prediction value, and judge whether early warning is needed according to the difference between the two. When the difference exceeds the set threshold range, give the early warning information. Through the construction of synchronous collection system of diesel generator coil temperature, real-time statistics of the collected coil temperature is carried out, and anomaly analysis is carried out according to the real-time predicted value, and early warning is carried out in case of any abnormality, so as to ensure the normal operation of diesel generator set.

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