Development of diagnostic systems for thermal facilities based on data processing

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Abstract

The complexity of modern industrial enterprises has led to the automation of equipment management, which includes sensors for monitoring the behavior of equipment and valves with remote control to act on undesirable events. Production automation physically protects the integrity of the plant. However, it reacts to abnormal conditions. The settings are set for the equipment in the operating range, and whenever the behavior of the equipment, such as steam pressure, is outside the specified range, an alarm is triggered and control equipment such as a valve is triggered to reset the equipment to a predetermined operating state.

Keywords: data processing, diagnostics, transfer function, identification

1 Introduction

Steam generating heat engines are the technological basis of many industrial facilities. This role assumes close attention on the part of both technologists and industrial automation specialists, because modern technological progress requires ensuring the optimal operation of the equipment, reducing energy consumption, increasing reliability, economy, and environmental friendliness with an increase in efficiency. A steam boiler as an object is a complex dynamic system with a large number of input and output interrelated quantities, therefore, when investigating it, in most cases, decompose on a separate monitor

2 Overview

The main task is to help operators to diagnose equipment, to forecast undesirable events, such as stopping the plant, to offer adequate values of set points and differences in the characteristics of malfunctions in the operation of process plants. The model consists of two main components:

- Individual data analysis: analysis of sensor data for future patterns, leading to undesired events for specific equipment.
- Analysis of group sensor data: analysis of the correlation of sensor data to determine the dependent factors between them and their errors in the data [1, 2].

3 Data processing

Statistical data is obtained at CHPP-2 using the Metran-910-4-8 sensors the following two most important monitoring channels:

- Boiler feedwater flow rate;
- Superheated steam flow rate

Data on the flow of feedwater (registered with the help of Metran-910-4-8, which has the serial number 2320) is shown figure 1.

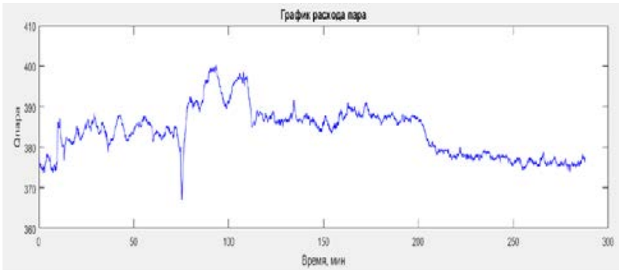

FIGURE 1 Steam flow rate

The developed mathematical models constructed based on differential equations of material and thermal balances are not entirely convenient for the purposes of operational diagnostics. The fact that the overhaul period of the boiler is long enough, therefore, monitoring the state of the boiler for a long time with the help of differentiated equations is not very convenient because of the need to use the computing resources of the computer to solve these equations.

A more convenient and economical form of mathematical description of the physics and chemical laws of the processes occurring in the boiler are algebraic equations. Therefore, we proposed a technique for obtaining transfer functions through various control channels that allow us to evaluate the state of the boiler by means of simple algebraic equations. Such a technique does not require a continuous solution of differential equations throughout the entire overhaul period [3, 4].

This approaches is based on the processing of statistical data obtained from a real object through various control channels and recovery, both the structure of transfer functions, and the values of the coefficients of these algebraic relations.

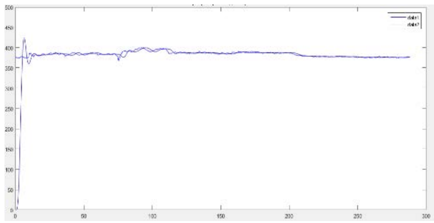

FIGURE 2 The graph "data 1" characterizes the signal after filtering and the graph "data 2" signal before filtering

As a result of identifying the object by input and output parameters, a characteristic curve of the object was constructed (Figure 2), which describes its operability. This characterizing curve depends on the transfer function W(s) indicated on formula

The input-output ratio is a classical transfer function whose coefficients are identified with statistical processing of data from sensors [5].

$$\frac{1.281}{1.7s+0.0006861}, \quad (1)$$

The transfer functions obtained with the help of the MATLAB tool for the most important and representative control channel: "Water flow rate - Steam flow" for different time intervals are presented in the table 1

TABLE 1 Transfer functions from 05/25/2017-07/01/2017

Dates	Channels	Transfer functions
05.25. 2017	Water flow rate - Superheated steam flow rate	$\frac{0.02767}{0.45s + 0.000944}$
06.26.2017	Water flow rate - Superheated steam flow rate	$\frac{0.03991}{0.1s + 0.004355}$
07.01. 2017	Water flow rate - Superheated steam flow rate	$\frac{0.01482}{0.4s + 0.01037}$
20.07.2017	Water flow rate - Superheated steam flow rate	$\frac{4.99}{0.4s + 0.01037}$

Modeling the channel "Water Flow and Superheated Steam Flow" with first-order transfer functions with different coefficients that were obtained by identification showed the dynamics of the change, which is a non-stationary operating mode that can cause undesired events at the site.
Therefore, that due to the uneven loading of the boilers that make up the station, and their natural, uneven wear, the graphs should be periodically reviewed with the introduction of the necessary adjustment. It is most convenient to review the schedules after planned and unplanned regime-adjusting tests of boiler equipment.

4 Conclusion

Maintaining a given water level in the steam manifold is one of the main tasks that ensure reliable operation of the boiler. With a high water level in the boiler, boiler water can be thrown into the superheater and, as a result, the destruction of its structures from hydraulic shocks. The harmful phenomenon of entrainment into the superheater of wet steam together with the salts contained in it is also intensified. Salt deposits, in turn, cause:

- in superheaters - burnt pipes due to unacceptably high temperature conditions;
- in steam pipelines and track fittings - their failure, and also are the centers of intergranular corrosion;
- in the flowing part of the turbines - a decrease in efficiency, a decrease in the cross-section of the interblade channels.

These phenomena lead to the appearance of significant axial forces acting on the turbine rotor, which can cause the thrust bearing of the turbine to melt and lead to an accident.

References

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