ISSN 0040-6015, Thermal Engineering, 2013, Vol. 60, No. 2, pp. 130–136. © Pleiades Publishing, Inc., 2013.
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AUTOMATION AND HEAT CONTROL IN POWER ENGINEERING

A System for Controlling the Boiler Heat Load

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Abstract—The system controlling the load of a coal-fired boiler operating in the configuration with a common steam line that is used at cogeneration stations is considered. An analysis method is proposed, and the mathematical description of the controlled plant is obtained. Results obtained from a study of classic and adaptive control laws are presented.

Keywords: thermal load, drum boiler, general steam pipe, mathematical description, PID controller, adaptive algorithm

DOI: 10.1134/S0040601512100060

Mutually coordinated operation of many automatic control systems is required for controlling the technological process in a drum boiler. The following groups can be distinguished among such systems: systems for closed-loop control of steam boiler parameters, automatic protection systems, systems for controlling emissions of harmful substances, and systems for controlling auxiliary processes and installations [1]. Systems for closed-loop control of boiler parameters, the list of which comprises more than thirty ones [including the main controller, the controllers of heat load, total air, underpressure, mill loading, air mixture temperature, primary air, superheated steam, feed, etc.], is the most numerous and important group of these control systems.

In this paper, we consider a heat load controller (HLC), which may operate, depending on the boiler connection diagram (with a common steam line), either as a device subordinated to the main controller (when the boiler operates in a control mode) or independently (when the boiler operates in a base mode).

The heat load control loop in a fuel flowrate closed-loop control system [1, 2] can be represented by the diagram shown in Fig. 1. The signal for the boiler heat load is produced as the sum of signals for superheated steam flowrate G_{ss} and for variation rate of steam pressure in the drum p_{dr}.

The "Controlled plant" unit shown in Fig. 1 includes not only the corresponding part of the process system, but also a cascade chain of control loops comprising mill load controllers and primary air controllers.

The boiler heat load signal can be measured in a simple and reliable manner; however, its use involves certain drawbacks [1], the most significant of which is a slow response to variations of heat release in the furnace via the channels of uncontrolled disturbances (quality of fuel, nonuniform operation of fuel feed systems, variations of primary air flowrate, etc.). But since this scheme is often used in practical applications [1–4], a well-grounded calculation of such system is a topical issue.

MATHEMATICAL DESCRIPTION

In view of the fact that the major part of equipment used at thermal power stations has been in operation for a long period of time and that it is often subjected to repairs and modernizations, an experimental method seems to be the most promising one for obtaining the mathematical description of a plant. If it is difficult to directly take acceleration characteristics, the method suggested in [2] can be used.

In 2009–2010, investigations were carried out on the BKZ-420-140-7 boiler No. 1 at the Blagoveshchensk cogeneration station [4], as a result of which a set of acceleration characteristics in the closed-loop system was obtained for the following channels: "the setpoint assignment for the heat load controller (HLC)—steam flowrate $W_{ss}(p)$ and the HLC setpoint assignment—pressure in the drum $W_{prs}(p)$. Three working points were selected from the whole set (Fig. 2) characterizing the variation range of plant parameters to the fullest extent (Table 1) in different operating modes of the mills, at different loading of mills, and when changes occur in the boiler steam output. The last line in Table 1 contains the averaged coefficients of transfer functions (denoted as the middle point).