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STEAM BOILERS, POWER FUEL, BURNER FACILITIES, AND AUXILIARY EQUIPMENT OF BOILERS

The Improvement of the Effectiveness of Using Natural Gas in Hot-Water Boilers by Means of Condensing Economizers

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Abstract—The paper describes the results of the study of the mathematical model of a condensing economizer (CE) interacting with the technological parameter of the particular district heating station. This model has been developed by the authors. It is shown that the CE, due to condensation of water vapor and augmentation of convective heat exchange between products of natural gas combustion, makes it possible to save up to 8% of fuel.

Keywords: heat utilization, water vapor contained in exit gases, energy saving, condensing economizer, thermophysical calculations, chimney stack protection, natural gas, heavy fuel oil

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When firing natural gas, part of the thermal energy is lost with water vapor contained in exit gases. This vapor can be considered as a secondary energy source (SES) that accounts for up to 12% of fuel consumption.

The main feature that prevents the implementation of these SESs is that they can only be used in the narrow range (from 58 to 45°C) of temperatures of the return district heating water to which heat is transferred.

The second feature is that condensation of water vapor from flue gases in a condensing economizer occurs with a solution of O_2 and CO_2 in this condensate; both these substances cause prohibitively fast corrosion of low-carbon steels, therefore, for making a heat exchanger and boiler back-end surfaces stainless steel, the cost of which is about 10 dollars/kg, should be used. In the 20th century the use of stainless steels for these purposes has been ruled out because of their higher cost as compared to the cost of fuel. This fact prevented the utilization of latent heat of condensation of water vapor contained in flue gases. Today and in the near future the relative price for fuel is increasing and will continue to increase and the situation is changing.

Hot-water boilers that serve a district heating network (a building) with a reasonably low temperature of the return district heating (DH) water during a rather long part of the heating season, provide the unique opportunity for utilizing heat contained in water vapor. In this case heating of the DH water by 1.0°C is equivalent to savings of 1.5% of the fuel. Condensing economizers are widely used in Europe, and they are produced commercially [1]. On the territory of the former USSR the condensing economizer has operated successfully over a period of several years at the KVGM-100 boiler installed at the Imanta combined heat and power (CHP) plant (Riga, Latvia).

The utilization of heat of condensation at a CHP plant is possible for heating the return DH water, but this involves energy loss due to expulsion of corresponding turbine extractions (this scheme has not been discussed in the present paper).

As the relative price for fuel rises, in the technical literature and on the Internet, the number of publications and advertisements on utilizing latent heat of vaporization by means of "wet" non-contact condensing economizers (Fig. 1) increases as well [11–13].

In the scheme (see Fig. 1) the arrangement of the drainages for water vapor condensate is not shown, but their quantitative characteristics and material costs of the effluent neutralization are discussed below in the section "Environmental aspects of the use of condensing economizers."

Hereafter, attention will only be given to condensing economizers connected to hot-water boilers in which the DH system water is heated. According to materials published abroad [1–3], with the temperature chart for the DH system water 90/70°C, fuel saving is 7%, with the temperature chart 75/60°C, 10%, and with the temperature chart 120/70°C, 12.5%. It is of fundamental importance that the sources of fuel saving are a hot-water boiler (a heating plant) together with heat consumers, which form the temperature of the return DH water.

The technology of fuel saving with the use of condensing economizers has acquired an industry-wide scale, and its introduction is determined by psychological barriers only. For example, in the Belenergo system there are about 45 district heating stations with the temperature charts for the DH water being 120/70°C,