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THE USE OF THERMAL METHODS TO PROTECT THE EXHAUST-CHANNELS OF BOILERS EQUIPPED WITH HEAT-RECOVERY UNITS

Summary. *Thermal methods for protecting the exhaust-ducts of boiler plants from corrosion damage due to the formation of condensate on their inner surface are considered. Methods such as are proposed and investigated: bypassing exhaust-gases, mixing with dry heated air, heating in a surface heat-exchanger - gas heater. The use of these methods will significantly improve the thermal and humidity condition of chimneys and increase their service life.*

Key words: *corrosion destruction, condensation mode, gas-exhaust ducts, gas preheater.*

Condensation in the gas-exhaust ducts of boilers is a problem that hinders the widespread introduction of heat-recovery technologies with deep cooling of exhaust-gases. The condensation on the inner surface of gas-outlet channels causes them to corrode. This destruction leads to a significant reduction in the life time of this tract, especially chimneys [1].

The main parameters that determine the condensate formation in a chimney are: gas temperature t_g, dew point t_d of water vapor in exhaust-gases and temperature of the inner surface of the gas-outlet channel t_s. A decrease in the gas temperature t_g, other things being equal, a decrease in the surface temperature t_s and brings it closer to the dew point t_d.

To prevent condensation in the chimney without changing its design is possible in two ways. The first method increases the temperature t_g, and the second reduces the dew point t_d, which depends on the moisture content of exhaust-gases. Consequently, the prevention of condensate formation can be provided by heat and humidity treatment of exhaust-gases. This treatment reduces the relative or absolute humidity of the gases. This treatment is carried out with the use of thermal methods to protect the gas-exhaust ducts [2]. This is

the partial bypassing method (passing a part of χ gases from the boiler past heat recovery exchange), the air method (mixing a part γ of the heated air to the exhaust-gases after the heat-recovery exchanger) and the method of heating exhaust-gases in the surface heat-exchanger – gas-heater.

To determine the effectiveness of the described methods, computational studies of the heat and humidity state in the gas-outlet channels in typical heating boilers are carried out. The performance characteristics of the boilers changed according to order. The design parameters of chimneys corresponded by those existing in boiler plants: height H = 45 m, internal diameter D = 0.8 m. In fig. 1, 2 presents typical results of performed studies. Herewith the working conditions of boiler houses are considered according to the regulations, when the boilers are loaded close to 50% of the nominal (at environmental temperature $t_{env} \approx 0$°C), some boilers are transferred to the nominal mode while the total number of boilers are reduced.

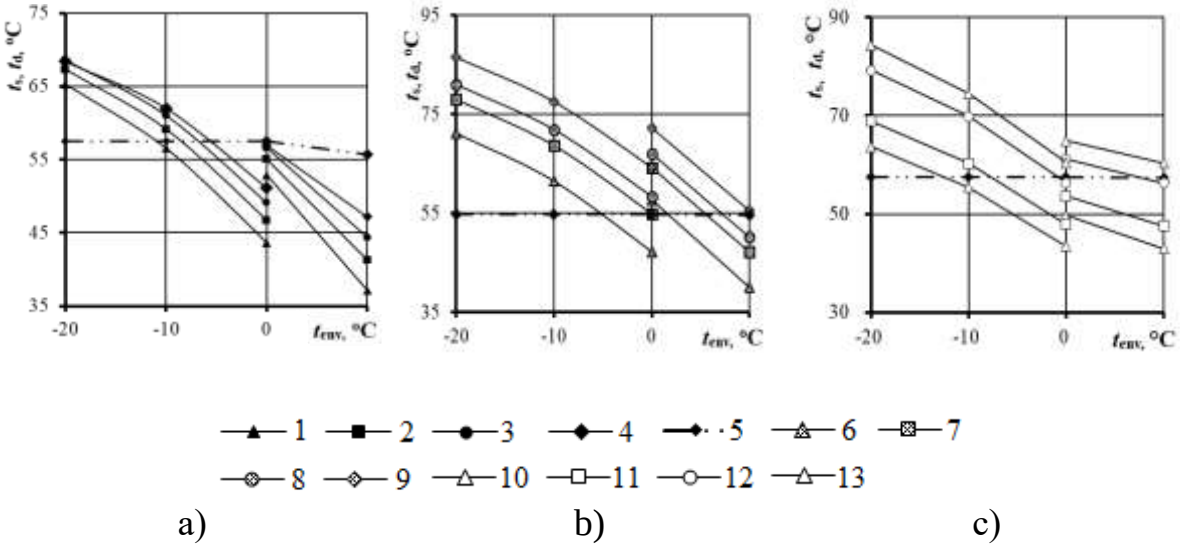


Fig. 1. Thermal characteristics of methods to prevent condensate formation in a metal chimney at the nominal temperature of exhaust-gases (after the boiler) t_{gn} = 200 ° C in different modes of operation of the boiler equipment

a) the bypassing method at different parts χ:

1– t_s at χ = 0 %; 2 – χ = 10 %; 3 – χ = 20 %; 4 – χ = 40 %; 5 – t_d.

b) the air method at different parts γ of air with temperature t_{dha} = 250 °C:

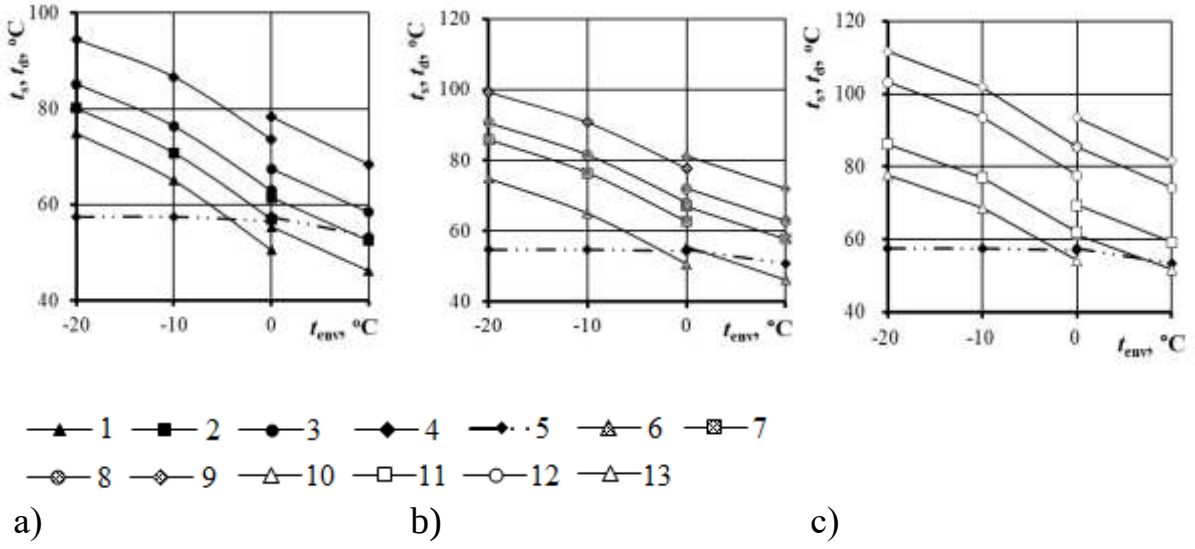
6 – t_s at γ = 0 %; 7 – γ = 8 %; 8 – γ = 12 %; 9 – γ = 20 %; 5 – t_d.

c) the method of heating at different level Δt of exhaust-gases:

10 – t_s at Δt = 10 °C; 11 – Δt = 20 °C; 12 – Δt = 40 °C; 13 – Δt = 50 °C; 5 – t_d.

Research results show that due to the increase in gas temperature t_g, the partial bypassing method provides the absence of condensation formation in the brick chimney of a heating boiler plant if part of χ gases from the boiler past the heat-recovery exchanger is 5 - 10% of the total exhaust-gases consumption. For a metallic chimney this method has positive results at a high temperature of exhaust-gases (> 180 ºC) and at boiler operation in modes approximately equal to the nominal one. For other mode, bypassing hot gases χ exceeds 50%.

The air method is designed to increase the temperature and reduce the humidity of a mixture of gases and air. This provides an increase in the internal surface temperature t_s and a decrease in the dew point t_d. In the studies the temperature of the mixed hot air changed in the range of 150 - 250 ° C. The absolute humidity of the air was about 0.1 kg / kg d.a. (dry air).



a) b) c)

Fig. 2. Thermal characteristics of methods to prevent condensate formation in a brick chimney at the nominal temperature of exhaust-gases (after the boiler) t_{gn} = 160 ° C in different modes of operation of the boiler equipment

a) the bypassing method at different parts of χ:

1– t_s at χ = 0 %; 2 – χ = 10 %; 3 – χ = 20 %; 4 – χ = 40 %; 5 – t_d.

b) the air method at different parts of γ of air with temperature t_{dha} = 250 °C:

6 – t_s at γ = 0 %; 7 – γ = 8 %; 8 – γ = 12 %; 9 – γ = 20 %; 5 – t_d.

c) the method of heating at different level Δt of exhaust-gases:

10 – t_s at Δt = 10 °C; 11 – Δt = 20 °C; 12 – Δt = 40 °C; 13 – Δt = 50 °C; 5 – t_d.

The performed computational studies have shown: the implementation of the air method ensures the absence of condensate formation in the chimney in case of a part of hot air in the total consumption of exhaust-gases equal to 3-25%. Smaller values correspond to brick chimneys and large values – to metal ones. It should be said that the application of the air method is implemented in boilers that have air heaters.

The method of heating cooled flue gases is the most versatile for use. It provides the absence of condensation formation during the preheating of exhaust-gases by the amount of Δt in the gas-heater installed after the heat-recovery exchanger. For preheating of gases heat-transfer agents such as water heated in a boiler with a temperature of 95–155 ºC or hot exhaust-gases with a temperature of 300 to 350 ºC, which are sent from the convective part of the boiler, are used.

The results of calculated research show; that the level of gas heating Δt required for the absence of condensation formation in the chimney varies in a range of 10 – 50 °C depending on the characteristics of the mode of the boiler plant and the type of chimneys.

The use of these thermal methods will contribute to a significant improvement in the heat and humidity state in chimneys and increase their durability.

References

1. Dolinskiy A.A. Basic principles of heat recovery technologies for boilers of the low thermal power / A.A. Dolinskiy, N.M. Fialko, R.A. Navrodskaya, G.A. Gnedash // Industrial heat Engineering. 2014. № 4. P. 27-36. (in Russia)

2. Fialko N.M. Heat methods of the gas-escape channels of boiler installations by heat-utilization technologies application / N.M. Fialko, R.A. Navrodskaya, S.I. Shevchuk, G.A. Presich, G.A. Gnedash // Scientific Bulletin of UNFU. 2017. Vol. 27, № 6. P. 125-130. (in Ukrainian)