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RESEARCH OF EXERGETIC LOSSES IN HEAT TRANSFER PROCESSES FOR LAMELLAR AND SMOOTH TUBE AIR HEATING HEAT RECOVERERS

Summary. *The study results of local exergetic losses in heat transfer processes for lamellar and smooth-tube air-heating heat recovers of boiler plants at different values of technological parameters are presented. It is established that for increase of exergy efficiency of heat recovery systems it is necessary to reduce exergy losses at heat transfer from a wall to air and to use lamellar heat-recovery units as much as possible.*

Key words**:** *exergy losses; heat recovery systems; air-heating heat recovery units.*

Introduction. The decision on the feasibility of using one or another type of heat recovery units in utilization schemes should be based on comprehensive studies that require the use of modern methods based on the exergy technological approach. The use of such methods allows us to determine the conditions for increasing the exergy efficiency of heat recovery systems, which determines the importance and relevance of the research.

Problem statement and research method. Currently, the study of the efficiency of heat and power equipment based on the exergotechnological approach allows us to study various types of exergy losses in complex power plants, as well as in their individual elements [1-5].

The paper studies local exergy losses in heat transfer processes in lamellar and smooth-tube air-heating heat recovery units of boiler plants. Exergy losses are considered as criteria for assessing the efficiency of heat recovery units. Ways to reduce losses of a certain type in order to increase the efficiency of heat recovery systems are outlined.

Purpose of the work, materials and research methods. The aim of the work is to establish the patterns of influence of technological parameters of lamellar and smooth-tube air-heating heat recovery units on their exergy losses in heat transfer processes through flat and cylindrical walls.

For calculating exergy losses in heat transfer processes, formulas obtained within the framework of a complex methodology were used, which is based on integral equations of functional analysis and differential equations of heat transfer theory.

Research results. The exergy losses in air-heating heat recovery units in the processes of heat conduction, heat transfer from flue gases to the wall and heat transfer from the wall to the air are considered. Formulas for calculating exergy losses in flat and cylindrical walls of heat recovery units are given:

$$E^{p}_{\mathrm{los},\lambda} = \frac{T_0 Q^2 \delta}{\lambda F T_{\mathrm{w}1} T_{\mathrm{w}2}}, \; E^{p}_{\mathrm{los},\alpha 1} = \frac{T_0 Q^2}{F \alpha_1 T_{\mathrm{w}1} T_{\mathrm{w}2}}, \quad E^{p}_{\mathrm{los},\alpha 2} = \frac{T_0 Q^2}{F \alpha_2 T_{\mathrm{w}1} T_{\mathrm{w}2}}.$$

$$E^{c}_{\mathrm{los},\lambda} = \frac{T_0 Q^2 \ln \frac{r_2}{r_1}}{2\pi\lambda l T_{\mathrm{w}1} T_{\mathrm{w}2}}. \; E^{c}_{\mathrm{los},\alpha 1} = \frac{2Q^2 T_0 (r_1 + 2r_2)(r_1 + r_2)}{r_2{}^2 F \alpha_1 (T_{\mathrm{g}} + T_{\mathrm{w}})^2}; \; E^{c}_{\mathrm{los},\alpha 2} = \frac{2T_0 Q^2 (r_1 + r_2)}{r_1 F \alpha_2 (T_{\mathrm{a}} + T_{\mathrm{w}})^2}.$$

where: E – exergy; Q – heat output; F – surface; r_1, r_2 – outer and inner radii of tubes; T_0 – ambient temperature; δ– wall thickness; α – heat transfer coefficient; λ – heat conductivity coefficient. Upper indices: p – plate; c – cylinder.

Lower indices: losλ, losα1, losα2 – exergy losses during heat conductivity and heat transfer; $w1$, $w2$ – walls on the side of flue gases and air; α1, α2 – heat transfer coefficients from flue gases to the wall and from the wall to air.

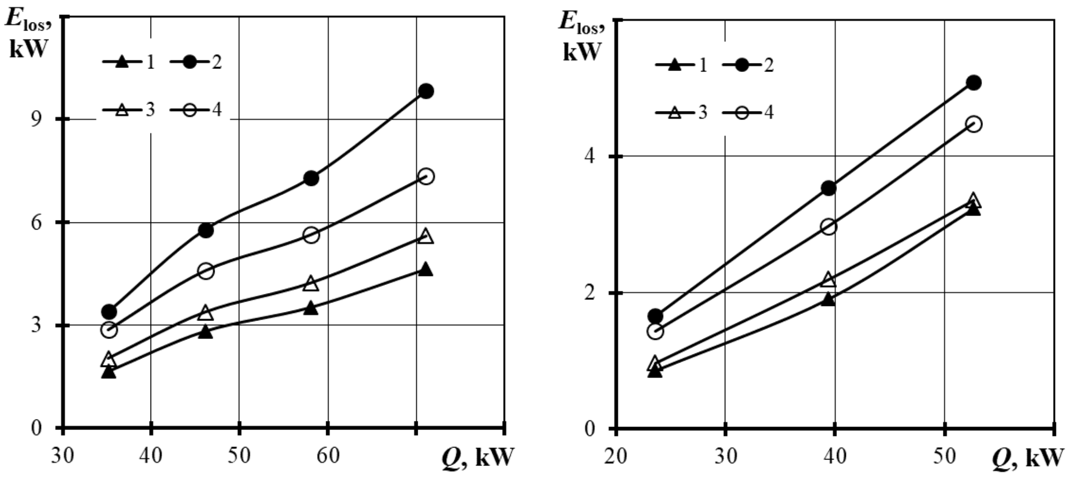
Exergy losses at the input and output of heat recovery units were determined for different values of heat output of heat recovery units and for two areas of ambient temperature change (Table 1, Fig. 1, 2).

Table 1

Average values of exergy losses at the input and output of heat recovery units in heat conduction processes

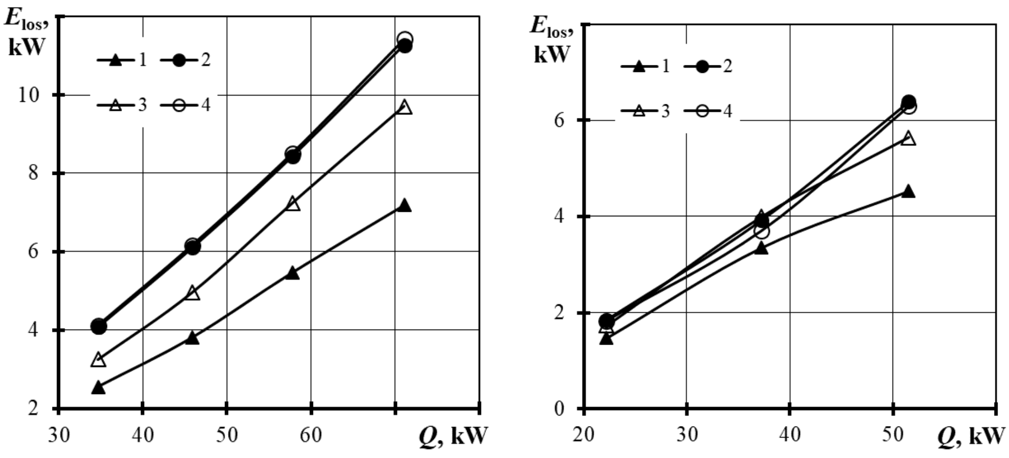
T_0°C	-20 – -5				0 – 10		
Q,kW	71,1	58,1	46,1	35,2	52,6	39,4	23,6
$E^{p}_{\mathrm{los},\lambda}$ kW	0,025	0,015	0,010	0,0065	0,015	0,0085	0,003
Q, kW	71,1	57,8	45,9	34,7	51,5	37,2	22,2

$E^{c}_{los,\lambda}$ kW	0,060	0,045	0,030	0,020	0,040	0,025	0,009



a) *b)*

Fig. 1. Exergy losses for a lamellar heat recovery units depending on its heat output during heat transfer from flue gases to the wall (1, 3) and from the wall to air (2, 4) at the inlet (1, 2) and outlet (3, 4): a) the range of T_0 change is (-20 – -5°C); b) the range of T_0 change is (0 – 10°C)



a) *b)*

Fig. 2. Exergetic losses for a smooth-tube heat recovery units depending on its heat output during heat transfer from flue gases to the wall (1, 3 and from the wall to air (2, 4) at the inlet (1, 2) and at the outlet (3, 4): a) area of change T_0 – (-20 – -5°C); b) range of variation T_0 – (0 – 10°C)

As can be seen from the figures, for all types of exergy losses and process parameters, the losses under consideration for a lamellar heat recovery unit are lower than for a smooth-tube heat recovery unit. With an increase in heat output, the exergy losses of all types for heat recovery units increase. These losses have the lowest values for heat conductivity, and the highest values for heat transfer from the wall to air. Thus, to increase the exergy efficiency of heat recovery systems, it is necessary, first of all, to reduce exergy losses during heat transfer from the wall to air and to use lamellar heat recovery units of various types as much as possible for heat recovery.

Conclusions.

1. The exergy losses for lamellar and smooth-tube air-heating heat recovery units were calculated for different values of process parameters and their comparative analysis was carried out.

2. It was established that in order to increase the exergy efficiency of heat recovery systems that include the heat recovery units under study, it is necessary to reduce the exergy losses during heat transfer from the wall to the air and to use lamellar heat recovery units as much as possible.

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