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TYPES OF EXERGETIC LOSSES IN EXHAUST GAS HEAT UTILIZERS

Summary. *The paper presents the results of a study of exergetic losses of various types for individual modules of exhaust gas heat recovery units. The* *relative contribution to the total exergy losses in heat recovery plants of exergetic losses associated with nonequilibrium heat exchange between flue gases and wall, between wall and water or air, losses due to thermal conductivity and due to the movement of heat carriers is analyzed. Data for four types of exhaust heat recovery units are given. It is pointed out that the relative contribution of exergy losses due to heat transfer from the flue gases to the wall is approximately the same for all types of heat recovery units and significantly exceeds the contribution of exergy losses of other types.*

Key words: *heat utilizer, exergetic losses, exergo-dissipative function.*

Introduction. One of the main directions in solving the problems of energy saving in small energy is to increase the efficiency of heat recovery technologies for power plants of various types. Exergetic losses can serve as a criterion of thermodynamic perfection of heat utilization systems. New research in this area contributes to the creation of highly economical heat recovery equipment and significantly expands the possibilities of applying methods of exergetic analysis in various fields of knowledge.

Problem statement and research method. Most studies in Ukraine and in the world using the methods of exergetic analysis are focused on the development of effective technological systems that meet the conditions of thermodynamic reversibility of the processes occurring in them [1-10]. The aim of this study is to analyze exergy losses of various types for individual modules of exhaust gas heat utilizers and to determine exergy losses for which the relative contribution to the total exergy losses in utilizers is maximal. The research was carried out using the discrete-modular principle and a complex technique based on the methods of exergo-dissipative functions.

Research results and their discussion. The most efficient in terms of energy consumption is a technological system that meets the conditions of thermodynamic reversibility of all processes occurring in it. For such a system, exergy losses should be minimal. Exergetic losses in power plants occur in the following cases: during the transition of organized energy into heat, during nonequilibrium heat exchange, during mixing of dissimilar heat carriers, friction, mechanical, electrical and hydraulic losses, losses during throttling, etc. In this work, exergetic nonequilibrium heat exchange between coolants and the wall and the movement of coolants. The technique, using the concept of exergo-dissipative functions, allowed to separate exergy losses in separate modules of heat utilizers connected with heat exchange between flue gases and wall, between wall and water or air, losses due to thermal conductivity and due to heat carrier movement. The relative contribution of these exergetic losses of different types $C_{\alpha1}$, $C_{\alpha2}$, C_{λ}, C_{G} to the total losses of exergy E in heat recovery plants (Table 1) was determined. Four types of exhaust gas heat recovery units were considered: waste gas heat recovery unit heat utilizers included in the heat utilization systems of glass furnaces, and a condensate-type heat utilizer included in heat utilization systems for heating water in heating systems.

As can be seen from the table, the maximum exergy losses in the modules of all considered heat recovery units are associated with losses due to heat transfer from the flue gases to the wall. The relative contribution of these losses to the total exergy losses is approximately the same for all types of heat recovery units and averages 97.7%. The contribution of exergy losses associated with losses due to heat transfer from the flue gases to the wall significantly exceeds the contribution of exergy losses of other types. The contribution of exergetic losses due to thermal conductivity is practically unchanged in various heat recovery units. The relative contribution of exergetic losses during heat transfer from the wall to the corresponding heat carrier and during the movement of heat carriers differs slightly for water-heating and air-heating heat utilizers. This is due to the high heat transfer coefficient and high hydrodynamic resistance of water compared to air.

Table 1

The results of the calculation of the relative contribution of exergy losses of various types in the total exergy losses in heat recovery units

Type of heat recovery unit	Heat recovery module number	Exergetic parameter				
		$C_{\alpha 1}$, %	$C_{\alpha 2}$, %	C_{λ}, %	C_G,%	E,кВт
Heat recovery exhaust gases heat engine cogeneration installation	1	92,5	5,9	0,9	0,7	42,6
	2	93,3	5,2	0,8	0,7	41,4
	3	93,7	4,7	0,9	0,7	45,8
	4	93,5	5,0	0,8	0,7	42,6
	5	93,8	4,8	0,8	0,6	38,6
	6	93,9	4,7	0,8	0,6	34,7
	7	93,9	4,7	0,8	0,6	30,8
	8	94,0	4,6	0,8	0,6	27,1
Water heating heat recovery	1	93,9	4,5	0,8	0,8	66,9
	2	94,1	4,4	0,7	0,8	49,9
	3	94,1	4,2	0,8	0,9	32,1
Air heating heat recovery	1	93,7	5,1	0,7	0,5	88,7
	2	93,8	5,0	0,7	0,5	68,8
Condensing heat recovery	1	94,2	4,3	0,8	0,7	10,3
	2	94,0	4,4	0,8	0,8	16,0

Conclusions.

1. Using a discrete-modular principle and a complex methodology based on exergo-dissipative functions, a comparative analysis of the relative contribution of exergy losses of various types to the total exergy losses in waste heat heat recovery units was performed.
2. The type of exergy losses is determined, for which the relative contribution to the total exergy losses in utilizers is maximal.

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