Increasing the efficiency of heating systems through the use of direct contact heat exchange

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1 Introduction

All technologically developed countries of the world pay great attention to the development of the energy sector and strive to reduce the cost of fuel and energy resources. At the moment, the severity of these problems for our country has increased sharply. This is due to the fact that there was a severance of economic ties with the advanced countries of Europe and America. Approximately 90% of our small-scale energy was based on low-power boilers produced in European countries. In addition, low-power gas turbine power plants were widely used, which were used in various technological processes. Therefore, in the context of import substitution tasks, it is necessary to develop new technologies for the production of thermal and power plants.

Currently, in all heat exchange devices, from low-power heating systems to high-power boilers, the principle of heat transfer is carried out mainly through pipe systems to the coolant.

This paper discusses a new method of transferring heat to a coolant without pipes through direct heat exchange, which allows to increase the coefficient of performance (efficiency), reduce metal consumption and production costs. In addition, environmental processes are improved by reducing fuel consumption. The relevance of the problem of reducing fuel consumption is determined by the increasing cost of fuel and energy resources as a component of various technological processes and the possibility of improving the environmental situation by reducing harmful emissions and carbon dioxide (CO_2) emissions into the atmosphere.

This development relates to the field of thermal power engineering, mainly to heating systems for various liquids, in particular to heating and hot water supply systems, and is also used in various technological processes, including gas turbine engines of various powers [1-2].

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2 Materials and methods

For a long time, scientists and innovative engineers have been developing various ways to increase the efficiency of water boilers and heating units of various capacities. At the same time, developments were carried out in several directions: on the one hand, new methods were developed to reduce heat loss and more complete use of the coolant on the outside of the device, and on the other hand, internal structural units. One of the ways to use external energy-saving technologies is to use special paints based on water-dispersible acrylic composite materials. This type of paint reduces heat exchange between the structure and the environment, which is due to the use of titanium dioxide and hollow glass microspheres. It is also possible to note the achievements of efficiency of boiler plants due to deep utilization of exhaust flue gases [3].

As methods for increasing the efficiency of heating installations from the inside, one can note a reduction in scale formation in the heating systems of heat exchangers of heating installations [4]; increasing the efficiency of heat exchangers through the use of profile twisted tubes [5]; development of methods for improving the fins of heat exchangers [6]; use of pulsation cleaning methods [7]; the use of a built-in surface cooler in the heat exchange process [8]; increasing the efficiency of heat transfer through the use of a round cylinder in laminar pulsating transverse flows [9-11].

One of the options for heating water is to burn fuel in a furnace and heat the water with flue gases (patent RU 2117878, F 24 N 1/10).

There are also known developments aimed at improving hot water boilers, in which a firebox was installed with ceiling and side screens made of pipes, connected inlet and outlet manifolds, and adjacent pipes that are connected by tangential pipes to the end sections of the rising pipes of the convective panel (patent RU 21150047, F 24 N 1/34,). However, during operation it was noted that this water heating boiler does not work efficiently enough, firstly, due to the large number of pipes and secondly, because the heat transfer process occurs through the pipe wall.

The authors were tasked with carrying out the process of heat transfer from a heating source to a coolant without a special heat exchanger in the form of pipe structures of different configurations and different compositions. Analysis of literature data on this issue showed that a known method of transferring heat to a coolant without pipes due to direct heat exchange consists of supplying liquid coolant from above into the heating zone onto a rotating shell with the formation of a thin-film liquid layer of coolant (patent RU 2178125, F 24 N 1/16). This method allows for contact heat exchange between the heat source and the coolant. The disadvantage of this method is the complexity of the design and the difficulty of implementing the process of its implementation.

Analysis of similar processes in other systems has shown that a known system for implementing direct contact heat exchange between a heat source and a coolant by supplying a liquid coolant to the inner surface of the combustion chamber of a gas turbine engine. To ensure the stability of the water film, in this work it is proposed to rotate the combustion chamber with the formation of centrifugal force, which will contribute to reliable operation during operation (RF patent No. 2084674 F02K3/38, F02C3/30). But it is very difficult to implement this process, since it is necessary to organize the process of rotation of the combustion chamber. Thus, according to known data, the formation of a thin-walled layer of water-containing liquid on the inner surface of the combustion chamber of a gas turbine engine and on the inner surface of the heating unit housing can be achieved due to the influence of centrifugal force from the rotation of the structure. But practically implementing this method is very difficult. Therefore, the task was set to create a centrifugal force without rotating the system.

To solve this problem, the author proposed the following solution. The formation of the wall layer is carried out by supplying a water-containing liquid tangentially to the inner surface of the cylindrical combustion chamber or the housing of the heating installation and acting on the water-containing liquid with a guide wall. Thus, due to the influence of the guide wall and centrifugal force, a near-wall layer is formed, which moves simultaneously coaxially and tangentially rotating towards the base of the heating installation, which ensures direct contact heat exchange, reducing fuel consumption, harmful emissions and carbon dioxide into the atmosphere and increasing the service life of the heating system installations. Moreover, in a heating installation containing a heat source and a housing with a system for supplying liquid coolant to the inner surface of the housing, the outlet of the pipeline for supplying liquid coolant is directed tangentially to the inner surface of the housing, into the cavity formed by the inner surface of the housing, the outer surface of the guide wall and the end partition connecting these surfaces..

This heating system allows you to use, in addition to traditional heat sources, an infrared emitter, which will increase the efficiency of the entire system with the possibility of implementation in various fields of activity.

The technical essence of this method is illustrated by a drawing, which shows a diagram of the basic design of a heating installation for implementing the proposed method of heating the coolant liquid.

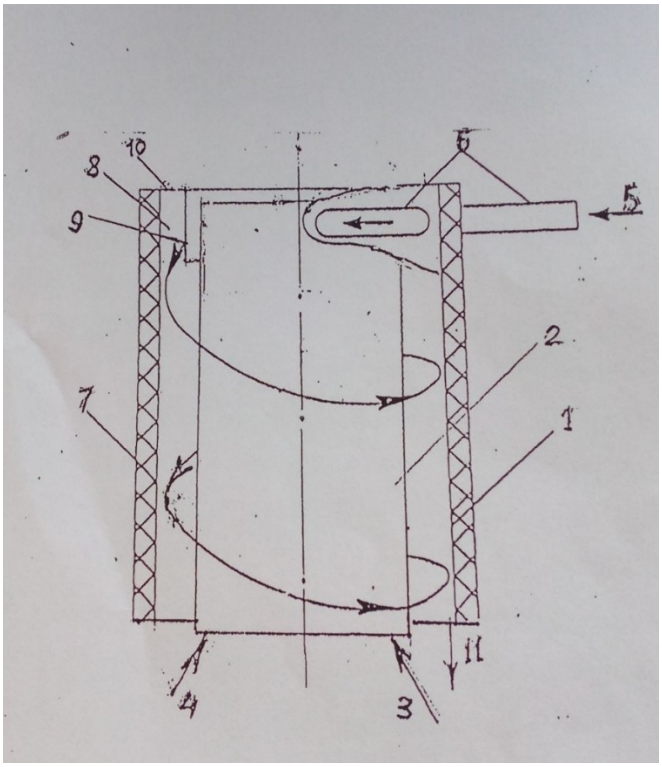

Fig. 1. Schematic diagram of the heating system installations for heating liquid coolant.

The heating installation contains a housing (1) in which a heat source (2) is located, into which fuel (3) and air (4), cold liquid coolant (5) is supplied, which is supplied from a pump (not shown in the drawing) through a pipeline (6) supplying liquid coolant tangentially to the inner surface of the housing (7) into the cavity (8) formed by the inner

surface of the housing (7), the outer surface of the guide wall (9) and the end partition (10) connecting these surfaces; removal of heated coolant liquid (11) for consumption.

The heating installation operates as follows: fuel (3) and air (4) are supplied to the heat source 2 located inside the housing (1), forming a combustion process on the outer surface of the heat source (2), and cold liquid coolant (5) is supplied to the heating zone. through the pipeline (6) tangentially to the inner surface of the housing (7) into the cavity (8) formed by the inner surface of the housing (7), the outer surface of the guide wall (9) and the end partition (10) connecting these surfaces. In this case, a near-wall layer of liquid coolant is formed on the inner surface of the housing, which moves simultaneously coaxially and tangentially, rotating towards the base of the housing (1) and the heated liquid coolant (11) is selected for consumption.

3 Results and Discussion

A new technology has been developed for heat exchange in heating systems by forming a near-wall layer, carried out by supplying a water-containing liquid tangentially to the inner surface of a cylindrical combustion chamber or the body of a heating installation and influencing the water-containing liquid with a guide wall. Thus, due to the influence of the guide wall and centrifugal force, a near-wall layer of liquid coolant is formed, which moves simultaneously coaxially and tangentially rotating towards the base of the heating installation, which ensures direct contact heat exchange, reducing fuel consumption, harmful emissions and carbon dioxide into the atmosphere and increasing the service life heating installation services.

In the process of implementing this development, the following results are achieved:

- Increasing the efficiency of heating systems due to direct contact heat exchange.
- Increasing the efficiency of heating systems by eliminating the intermediate heating system in the coolant pipes.
- Reducing metal consumption by eliminating a large structural element of the system in the form of pipes for heating the coolant liquid.
- Increasing the reliability of the heating installation by eliminating the pipe system for heating the coolant.
- This technology can be applied in various heating systems, as well as in gas turbine engines for various purposes.
- This heating system allows you to use, in addition to traditional heat sources, an infrared emitter, which allows you to increase the efficiency of the entire system with the possibility of implementation in various fields of activity.

4 Conclusion

- A new method is proposed to increase the efficiency of heating systems through direct contact heat exchange between the heat source and the coolant.
- To implement this method, a new technology for heat exchange in heating systems has been developed due to the formation of a near-wall layer of liquid coolant on the inner surface of the housing or combustion chamber. In this case, the near-wall layer of liquid is formed due to the force of centrifugal action and the action of the guide wall, which provides direct contact heat exchange, reducing fuel consumption, harmful emissions and carbon dioxide into the atmosphere and increasing the service life of the heating installation.

- This heating system allows you to use, in addition to traditional heat sources, an infrared emitter, which will increase the efficiency of the entire system with the possibility of implementation in various fields of activity.
- The proposed design can be used in heating systems, as well as in gas turbine engines for various purposes.

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