Reducing emissions into the environment during the operation of small-capacity boilers

Anastasiya Ivanova[1,2*], Tsolmon Khalzan[1], Viktor Ivanov[2]

[1] *Department of Thermal Engineering, School of Power Engineering, Mongolian University of Science and Technology, Ulaanbaatar, Mongolia*
[2] *Institute of Engineering & Technology, North-Eastern Federal University, Yakutsk, Republic of Sakha (Yakutia), Russia*
**Correspondence author. Email: anastasiia.ykt@gmail.com, ORCID: 0000-0002-1825-0097*

ABSTRACT
This article considers measures to reduce air pollution from autonomous heating facilities. At the present time autonomous heat supply is actively developing. Affordability, controllability, autonomy, economy allow to determine the choice of consumers. But unlike power plants, the design of small boiler units is quite simple. Such boilers have no tail heating surfaces and flue gas cleaning devices. Common solutions to improve energy efficiency often do not take into account the impact of emissions into the environment. This article proposes to consider ways to reduce the impact of emissions into the environment from a small boiler and a group of boilers. A comprehensive approach to improve the efficiency and ecological of the boiler is considered: analysis of the influence of fuel-air mixture parameters and increase of fuel efficiency, optimization of combustion process and reduction of harmful emissions formation; investigation of flue gas removal and dispersion of pollutants into the atmospheric air. This method will improve the efficiency and environmental friendliness of operation from a single boiler and determine the optimal location of a group arrangement of boilers of small capacity.

Keywords: *Combustion products, air-pollution control, low power boilers, gas boiler, long-burning solid fuel boiler, fuel efficiency, operational reliability.*

1. INTRODUCTION

Currently, the main direction of development of the energy sector is the search for ways to improve efficiency and energy saving. To improve the energy efficiency of heat supply systems, various ways are developed, comparative analyses of energy efficiency of various heat supply schemes are performed. However, these ways do not always reflect the impact on the environment. Human society as a part of nature can exist only in constant interaction with it [1]. The development of modern society is constantly accompanied by an increase in energy consumption, directly related to the use of natural resources. At the same time, emissions from industrial and domestic industries are increasing.

In order to realize a comfortable existence of modern and future generations, every energy-efficient solution must take into account the environmental condition.

One of the key ways to protect the air basin is the development and development of systems for rationing the negative impact on the environment [2]. But legislative measures have a long implementation period. For effect in the near future everyone should understand and make decisions for creation of the favourable environment for itself and the future generations [3].

Recently, special attention has been paid to the issues of reducing pollutant emissions from the combustion of fossil fuels. According to various sources, the level of emissions of harmful substances into the atmosphere from communal boilers is estimated at 15-20% of the total emissions of pollutants. In general, the volume and composition of pollutants significantly depend on the type of fuel used, the method and quality of its combustion, and the design features of the boiler and burner.

To date, there are four directions to combat pollutants in the surface atmosphere:

1. optimization of the fuel combustion process;
2. Purification of fuel from elements forming pollutants during combustion;

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3. cleaning of flue gases from pollutants;
4. dispersion of pollutants in the atmospheric air.

2. STUDY OF OPTIMIZATION OF FUEL COMBUSTION PROCESS

Providing the combustion process with an optimal amount of air has a great influence on the reduction of harmful emissions into the atmosphere. Combustion efficiency is determined by the temperature in the combustion chamber, but higher temperatures in the flame front contribute to the formation of NO_x, and its quantity is also influenced by the excess air ratio. Conversion of fuel *N* is more dependent on fuel: air ratio than it is on variations in combustion zone temperatures. Thus, a precise balance of air distribution and combustion temperature control must be maintained to make primary NO_x controls effective [4].

However, a reduction of the air excess is only possible until it leads to an intensive growth of incomplete combustion products that pollute the environment.

Development of heat generation systems for heat supply of settlements led to the formation of new approaches, aimed mainly at decentralization. Such autonomous heat supply systems as apartment and cottage systems are actively developing.

Small-capacity natural gas-fired boilers have a fairly high efficiency factor of 92% on average, which is the most efficient option for heat supply. But in fact, under operating conditions with outside air temperature of –35°C and below, there are significant deviations from the passport data. Analysis of emergency shutdowns of boiler plants in the Arctic zone showed that the largest number of heat supply interruptions is observed from November to February, during the period of the lowest air temperatures. The main technical cause of emergency shutdowns of heat generators is unsatisfactory operation of the chimney system, associated with the intake of cold air for combustion, during the period when outside air temperatures are –40 °C and below. Supply of air with negative temperature into the furnace affects the boiler efficiency, leads to increased fuel consumption and increased formation of combustible elements in the combustion products. Due to the large amplitude between the outdoor and indoor air, a large upward pull is created in the boiler volume.

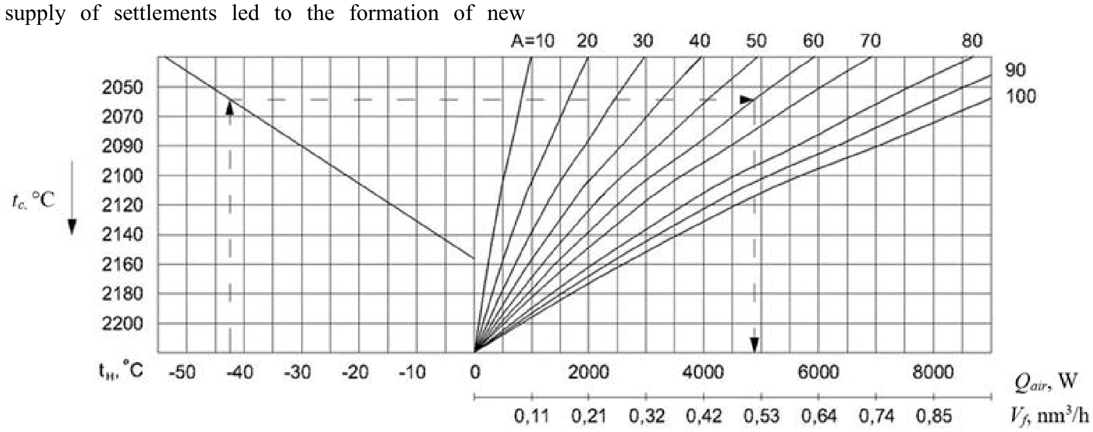

Figure 1 Nomogram for determining the amount of heat and consumption of natural gas depending on the parameters of the outdoor air (α_f=1,1)

This leads to an increase in excess air and the consequence of increased NOx values. In order to save energy, as well as to exclude and prevent emergency shutdowns of heat-generating units, a system analysis of gas-fired heat generators and their chimney systems has been conducted. As a result of the conducted research the grapho-analytical method of determining the amount of heat required to heat the air entering for combustion and the additional consumption of natural gas of small capacity heat generators was developed.

The given nomogram (Fig. 1) allows us to estimate the dependence of the efficiency of the gas boiler on the outside air temperature (t_{out}). With a decrease in the temperature of the air supplied to combustion and an increase in the excess air coefficient, the calorimetric temperature (t_c) decreases sharply. Changes in air parameters lower the calorimetric temperature from 6...20% or more. To provide the required thermal power, additional heat is spent on heating the incoming air (Q_{air}). As a result, the consumption of natural gas (V_f), increases or the necessary thermal energy is not provided at the normalized consumption, which reduces the efficiency of the boiler.

In search of ways to improve the efficiency of energy sector enterprises, as well as other industrial facilities that use equipment that burns organic fuel, the issue of using the potential of flue gases is not raised in the very first place.

The optimal temperature of the exhaust gases for different types of fuel and operating parameters of the boiler is determined on the basis of technical and economic calculations at the earliest stage of its creation.

But even despite the introduction of technologies and equipment for the most complete heat recovery, the temperature of the exhaust gases according to the current regulatory documentation should be in the range:

– 120-180°C for solid fuel boilers (depending on fuel humidity and boiler operating parameters),

– 120-160°C for fuel oil boilers (depending on the sulfur content in it),

– 120-130°C for natural gas boilers.

These values are determined taking into account environmental safety factors, but primarily based on the requirements for the operability and durability of equipment.

Thus, the minimum threshold is set in such a way as to eliminate the risk of condensate loss in the convective part of the boiler and further along the path (in the flues and chimney). When the flue gases are cooled to the dew point temperature and below, condensation of water vapor occurs, along with which NOx and SOx compounds also turn into a liquid state, which, reacting with water, form acids that have a destructive effect on the internal surfaces of the boiler. Depending on the type of fuel being burned, the temperature of the acid dew point may be different, as well as the composition of acids falling out in the form of condensate.

However, modern conditions of development allow us to reconsider this approach.

3. METHODS OF REDUCING POLLUTANTS GENERATED DURING COMBUSTION

To obtain an effective solution for reducing the pollutants formed during combustion, a comprehensive method is required: optimization of the fuel combustion process; cleaning the fuel from the elements forming pollutants during combustion; purification of flue gases from pollutants; dispersion of pollutants in the atmospheric air.

This paper considers the full-scale, experimental and computational study of the operation of autonomous boilers.

During the operation of boilers, the process of complete combustion of fuel is significantly affected by the characteristics of the incoming combustion air. In small boiler plants, the most common is the use of closed combustion chambers with external air intake. Such a system is safer, but at the same time from field studies it was determined that in areas with low temperatures the cold air entering for combustion is one of the main causes of fuel combustion failure. Purification of fuel from the elements formed during combustion of pollutants for natural gas is carried out just before its delivery to the consumer. For autonomous solid fuel plants, transport and storage of fuel before combustion is of great importance. During operation, a big role is played by the smoke exhaust system, here a significant amount of thermal energy is lost, there is an aggressive phase transition environment, and this system always receives less attention, because of which is often the most common cause of boiler malfunction and increased harmful emissions.

3.1. Natural gas

In conditions of low temperatures outside air the most optimal way to reduce emissions and increase the efficiency of the boiler is possible by reducing the temperature of flue gases and its useful use. In this case, the temperature of air necessary for combustion plays a key role. Fig. 2 shows a diagram of the installation with combined heating. The most rational is to heat the incoming air required for combustion, by using secondary energy resources - utilization of the heat of flue gases.

Based on the known dependencies, the thermal balance of the combined coaxial pipe with allowable simplifications has the following Equation (1):

$$\begin{cases} dQ_{air} = dQ_f + dQ_w \\ dQ_{air} = G_{air} c_{air} dt \\ dQ_f = k_i \pi (t_f - t_{air}) dy \\ dQ_w = k_j \pi (t_w - t_{air}) dy \end{cases} \quad (1)$$

Where: dQ_{air} – change in the heat content of the air required for combustion, W; dQ_f, dQ_w – change in the heat flux transmitted through the chimney structure from combustion products and water, respectively, W; G_{air} – amount of air, kg/sec; k_i, k_j – linear heat transfer coefficient from combustion products and water, respectively, W/(m·ºC); t_f – temperature of combustion products, ºC; t_w – water temperature, ºC; t_{air} - air temperature, ºC, t_{out} - outdoor air temperature, ºC.

After a number of transformations Equation (1), we obtain the dependence of the temperature of the air necessary for combustion Equation (2):

$$t_{air} = \frac{(k_i t_f + k_j t_w) - [k_i t_f + k_j t_w - (k_i + k_j) t_{out}] e^{-\left(\frac{\pi (h_i + h_j) v}{G_{air} c_{air}}\right)}}{k_i + k_j}, \quad (2)$$

Fig. 3 shows the graph of changes in the temperature of air required for combustion, depending on the outside air temperature.

Using an additional source of heat for air heating, allows increasing the temperature of incoming air into the circuit of heat generator up to 20% with a smooth pipe. Presented analytical dependence Equation (2) allows us to calculate the fields of outside air temperatures required for combustion in the coaxial chimney.

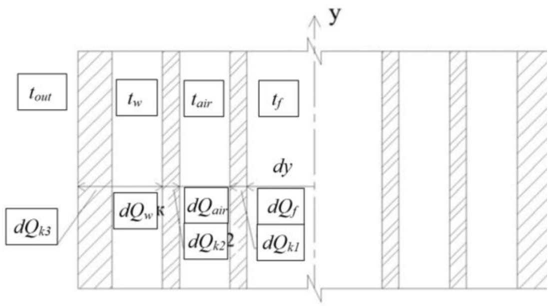

Figure 2 Calculation scheme of the plant with combined heating

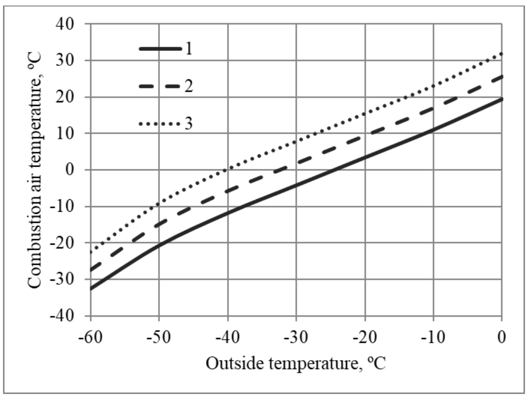

Figure 3 Variation of air temperature required for combustion at the temperature of combustion products: 1 -100°C, 2-150°C, 3-200°C

From the analysis of the obtained dependence, we can see that the air temperature depends on the heat transfer coefficient. For more heating of outside air temperature, it is necessary to intensify the heat transfer capacity of chimney systems.

3.2. Solid fuel

In view of the large development of individual housing construction in areas without gas distribution networks, solid fuel boilers are widely used also in areas with low outdoor temperatures. The main problem of operation of classic boilers is the need to load fuel up to 5 times a day, which leads to a lack of possibility to prepare fuel in advance in a standard way and reduces the comfort level of living conditions. To solve this problem, solid fuel boilers of small capacity with the principle of "top combustion" (long combustion boilers) were investigated. The boiler consists of two steel cylinders, with a cavity between them, which contains the coolant. The outside of the structure is covered with a heater, to reduce the heat loss of the coolant and the insulation of the outer walls from overheating, as well as to provide protection against thermal burns of the user. To improve the quality of combustion and heat transfer, on top of the boilers for natural gas is possible to reduce emissions in a comprehensive approach, taking into account the temperature reduction to prevent corrosion is not necessary to sacrifice the heat that is released into the atmosphere instead of doing useful work.

A distinctive feature of such boilers is that the combustion process takes place on a top-down candle principle, the upper layers burn and the lower layers are on standby without any heat release. The heating device is a cylindrical body, which contains a combustion chamber of fuel, grate, a tank for loading the coolant, the device for supply and distribution of air. Combustion takes place at low oxygen content, thereby increasing the fuel heat transfer time and giving less solid waste.

According to the results of field inspection, the operation of boilers of long (upper) combustion is accompanied by processes of soot formation of varying degrees and the formation of acidic condensates with subsequent destruction of chimneys, spontaneous ignition of soot, formation of microcracks and penetration of flue gases from the boiler to the living space Fig. 4.

These problems are associated with climatic operating conditions, combustion mode, features of the heating system and other factors. Technical solutions of thermal schemes of autonomous sources should take into account the peculiarities of the initial conditions: by type of heat generator, quality of source water, by design of heating systems, etc. Technical solutions require a thorough substantiation of the choice of thermal-hydraulic scheme, analysis of operating conditions, ensuring the reliability of functioning and protection of equipment from uncalculated modes of operation [6].

Slagging on high-temperature surfaces causes particular difficulties in the operation of boiler units, and prevention or reduction of the intensity of deposits is urgent.

Figure 4 Left - process of soot formation in the chimney cavity of the boiler, right - process of acid condensate formation on the boiler chimney

Scaling on heating surfaces is the result of a complex set of physical, chemical and aerodynamic processes, including condensation of moisture on the cooled surfaces of chimneys.

Also, solid fuel boilers are subject to wear as a result of solid particles entrainment, depending on the excess air, uneven combustion and flue gas velocity. According to [7], one of the main causes of failures of domestic boiler units is ash wear, accounting for 23%, the distribution of emergency failures. To ensure the normal operation of the heat generating unit, it is necessary to continuously supply air into the furnace for combustion, to provide the necessary speed of movement of hot gases and to remove the resulting combustion products with the help of draft blowers [8]. The chimneys of boiler units are operated in harsh climatic conditions with large variations in temperature, pressure, humidity and wind loads of the environment.

The main components of combustion products in chimneys are carbon oxides and nitrogen oxides, water vapor, sulfur dioxide, as well as solid ash particles.

The negative impact of flue gases on the metal structures of chimney systems is manifested in the form of acid corrosion and moisture filtration. As a result of full-scale and experimental research, the data was obtained, Fig. 5 shows the graph.

When selecting the boiler, the capacity of the unit is calculated with respect to the design temperature of the cold five-day period with the probability of 0.92. During operation the main part of the working heating season is occupied by the transition period with temperatures of –45...–20°C. At coal combustion depending on the ambient air temperature there is a regulation by changing the combustion air supply and transition to the smoldering stage.

The air supply is controlled by the set temperature of the coolant, which, when the value is reached, triggers the closure of air suction.

During 3 hours (the study period established by the author) at daily fluctuations of the ambient air temperature from –40 to –30°C in zones from 3 to 5 of the combustion process, an average of 6 periods of fluctuations with an amplitude of about 200°C are observed. The duration of zone 1 occurs during 3 hours, fuel charging takes 1 time per day.

When the ambient air temperature rises from –30°C to –25°C, the number of fluctuations decreases to 4 and has a non-uniform character. Also during the ignition there are higher temperatures by 100°C above. The coolant temperature is maintained unevenly, the temperature curve duplicates the combustion process in the furnace. Overheating, excessive indoor air temperatures in the rooms are observed.

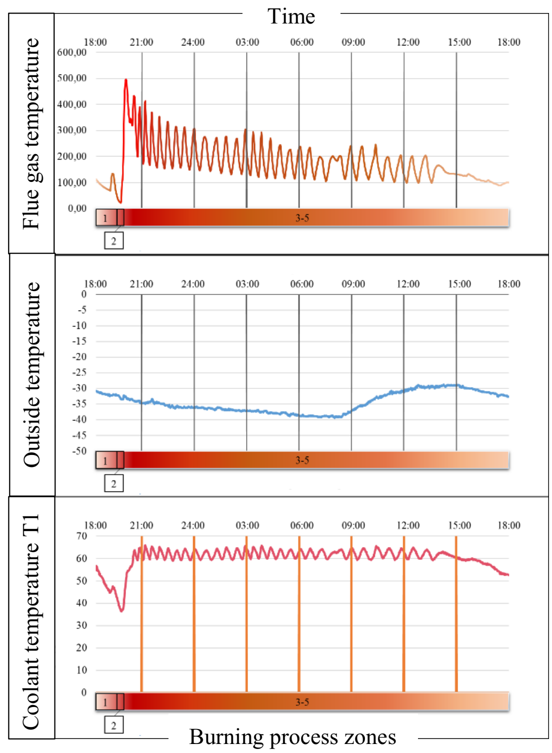

Figure 5 The process of burning lignite in the boiler in a day. Zones of the combustion process: 1 - attenuation; 2 - no combustion, slag removal, fuel stowage; 3 - start of firing, ignition; 4 - combustion. 5 - attenuation

One of the main negative features of boilers with long combustion principle "upper combustion" is the inability to regulate the boiler by the thermal regime of the boiler, the amount of fuel relative to the temperature of the coolant. During operation, when the outside temperature rises, according to the temperature schedule, the coolant temperature changes and is set at the boiler. Boiler automatics allows to keep the coolant temperature at set values by ignition and attenuation of fuel. In periods of low temperatures the number of fluctuations is more frequent, with a further increase there are observed overflows and excessive values of the coolant temperature.

For operation of this type of boilers, the important point is the selection of the boiler in power, taking into account the type of heating system, types of heaters, etc. Power reserve in such a system should be minimal, the boiler power as close as possible to the operating temperature values.

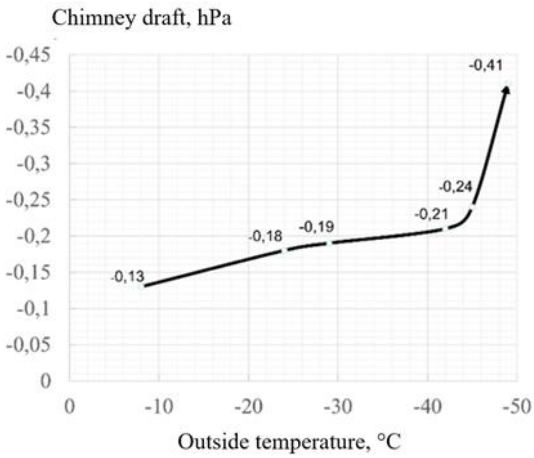

Figure 6 Diagram of natural draught in the chimney of solid fuel long combustion boiler on the temperature of the outside air

Fig. 6 shows a graph of changes in the chimney draft. The point of phase transition in the second range (−43°C), when the boiler loses its operational properties, is revealed.

The smouldering process passes into intensive combustion of the upper layers of coal, increasing fuel consumption, as well as reducing the efficiency factor. Thus, at peak negative temperature values of the outside air during operation of the long combustion boiler there can be observed an increase in the coefficient of excess air with increased draft due to the temperature difference between the outside air and the temperature inside the boiler. This leads to an increase in the volume of combustion products escaping through the chimney, and thus reduces the heat output of the boiler, increasing the value of the excess air ratio and consequently an increase in harmful emissions.

From the graphs depending on the temperature on the supply pipeline and the temperature of flue gases can be seen the distribution of zones of the fuel combustion process.

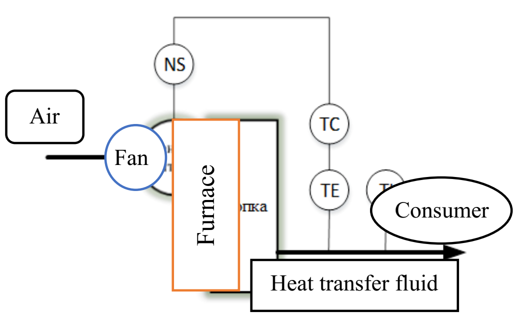

Figure 7 Functional diagram of the automation of air control in boilers with "upper combustion".

Zone of kindling is expressed by increased blowing of air to start the combustion process and increased values of temperature of flue gases about 400-500°C, the average duration of this period, to establish the optimal combustion process is 30 minutes-1 hours, 2 zone - the main process of upper combustion with continuous air supply through the air distributor, 3 zone - attenuation with a characteristic decrease in temperature at the supply pipeline, the duration is about from 4 to 6 hours, 4 zone - no combustion, cleaning and loading fuel. The duration of zone 3 is observed with a sharp drop in temperature in the supply pipeline, which leads to violation of comfort conditions and insufficient heat output of the heating system.

To improve comfort conditions and increase the useful operating time of the boiler, the duration of zone 3 should be reduced and the temperature in the supply pipeline should be increased.

To do this it is necessary to switch from "top combustion" to the classic principle of solid fuel combustion when the 3rd zone is reached. For the transition it is necessary to supply the actual amount of air for complete combustion. We provide this by means of air supply by the distributor and bottom blowing through the grate, limiting the furnace space volume. For efficient operation of the system, this process is automated.

To determine the optimum control it is necessary to find values kp proportional coefficient of the regulator and Ti constant coefficient of integration of the PI-regulator. Which will allow to regulate the temperature on the supply pipe T1 depending on the supply flow rate.

Fig. 7 shows a functional diagram of the automation of air flow regulation in boilers with "upper combustion".

According to the developed scheme, a simulation was performed on MATLAB Simulink program. From the experimental data we determined for the adventitious function of the object k_{ob}=0.39, the constant coefficient of the object T_l=3600sec. As a result, we obtained the dependence Equation (3):

$$W_{ob} = \frac{0{,}39}{3600 \cdot s + 1}, \quad (3)$$

Where: W_{ob} – transfer function of the object; s - Laplace variable.

In the process of simulation, we determined the optimal values of the proportional coefficient k_p = 3.43, the constant coefficient of integration function T_i=0.001904 PI-controller. These coefficients determine the regulation of the long combustion boiler. Fig. 8 shows the dependence of the difference between the average temperature value on the supply pipeline and the temperature change $T1$.

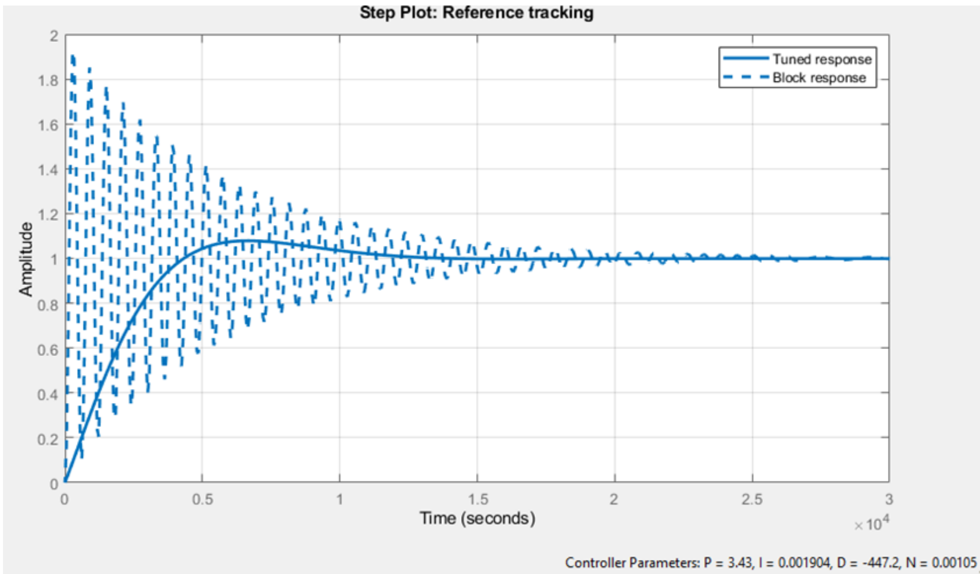

Figure 8 Transient control characteristic of the difference between the average temperature value in the supply pipeline and the time variation of T1

Fig. 8 shows that without regulation active oscillations are observed, taking into account the found coefficients the regulation process is levelled and has smoother lines, which allows the most effective regulation of the air supply process, depending on the decrease in temperature *T1*. Thus, the temperature on the supply pipeline is set.

For each type of fuel and boiler output it is necessary to determine the appropriate fuel layer of the combustion type transition.

4. ANALYSIS OF THE DISPERSION OF POLLUTANTS IN THE ENVIRONMENT

In [5] a comparative analysis of assessing the impact of technical solutions for district heating on air pollution is performed. The comparison was made for three technical solutions for heat supply of areas of different types of buildings with approximately the same heat load: 1. a household building with a centralized heat supply system and one source of heat; 2. a household building with the installation of a heat generator in each cottage; 3. multistory buildings with apartment systems of heat supply. In work application of natural gas was considered. As a result, researches have shown at multistory apartment heating there is a decrease in total mass of emissions at the expense of decrease in total installed capacity of all heat generators. Changing the capacity and height of the chimney leads to minimal pollution from the group chimney. However, the analysis of overlapping of dissipation zones from all sources of pollution has shown that the option of apartment heating is inferior in terms of environmental performance to other solutions considered. Eightfold overlapping of dissipation zones in apartment heating and fourfold overlapping in cottage heating is due to the corresponding building density. This factor should be necessarily considered when developing architectural and planning concepts and technical solutions for heat supply.

The process of dispersion of combustion products directly depends on the height of the chimney and the velocity of the combustion products.

For small natural gas-fired boilers operated in areas with cold climates, the air duct must be of such a design and thermal insulation that no moisture accumulates in it. The temperature on the internal surfaces should be above the dew point temperature. When burning natural gas condensation on the walls of the chimney begins at a wall temperature below 55-57°C (dew point of methane combustion products). The amount of condensate can be very large. The presence of a large amount of water inside the chimney causes serious problems at ambient temperatures of –45°C and below. And also the temperature on the surface of the room, bordering the chimney, reaches the dew point temperature and as a result the condensation of moisture in the air of the room.

In order to consider these problems the mathematical modelling of the standard configurations of smoke exhaust and a separate chimney design with additional heating of combustion products heat was carried out on the ANSYS FLUENT software package. Calculations were performed for 3 types of cross-current coaxial chimneys. Each scheme is described below.

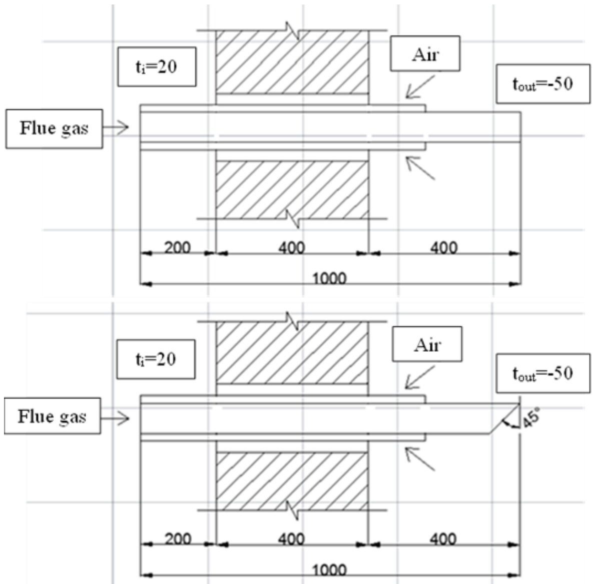

Figure 9 Above scheme a - coaxial chimney outlet with a straight chimney head, below scheme b - coaxial chimney outlet with a change in the slope of the chimney head of the flue gas

Scheme 1. Coaxial pipe, smooth pipe in pipe principle, cross-current. Internal contour - combustion products, external contour - air (Fig. 9.a).

Scheme 2: Coaxial tube, smooth tube in tube, cross-current. Internal circuit - combustion products, external circuit - air (Fig. 9.b).

Scheme 3. Coaxial tube-in-tube heat exchanger, cross-current, inner tube D1 is finned on the outer side, outer tube D3 is coiled with tube D2 on the inner side (Fig. 10).

The boundary conditions for each computational scheme correspond to the accepted ones. Calculations were performed for different temperatures of outdoor air from 10°C to −50°C in the range of velocity of combustion products from 2-8m/sec.

Below are the graphical results of the simulation mathematical modeling.

If you mentally enter the thermometer into the area filled with air and lead it along the chimney, the thermometer will record the following temperature change (Fig. 11, 12).

From the graphs we can see that on the upper surface of the tube at a distance of 0.8 m there is a jump and then a sharp decrease in temperature. Averaged over the cross-sectional area of the pipe, the temperature of the air fed into the heat generator is 241.12 K.

Simulation results of the second model - straight nozzle. Fig. 13 shows the results of the simulation mathematical modelling of distribution of the combustion products temperature at the outlet into the environment with the temperature of −50°C at speeds of 1-6 m/sec.

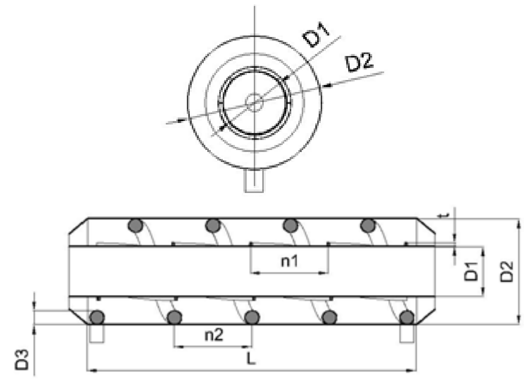

Figure 10 Scheme of the device chimney system with intensified heat dissipation

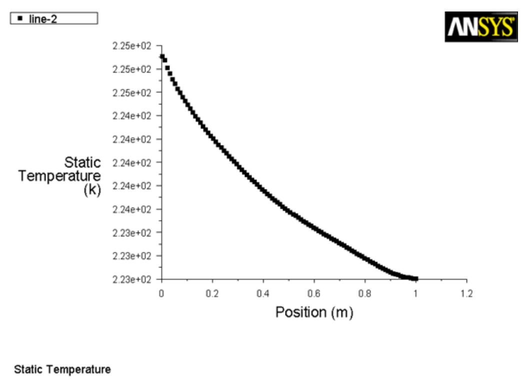

Figure 11 Temperature distribution in the lower (relative to gravity) part of the pipe, heat generator on the left, ambient on the right

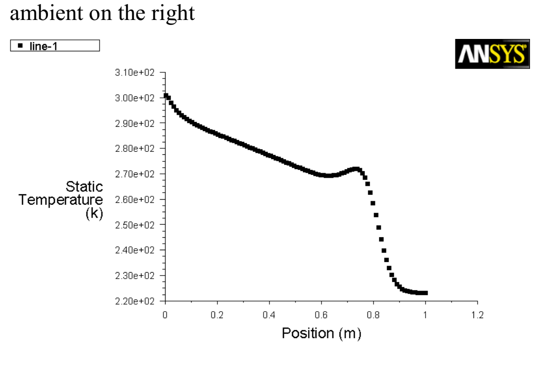

Figure 12 Temperature distribution in the upper (relative to gravity) part of the pipe, with the heat generator on the left and the environment on the right

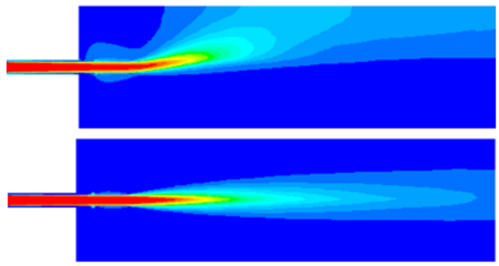

Figure 13 Temperature distribution along the vertical section. The force of gravity is directed downward

Figure 14 Zero temperature isosurface (side view)

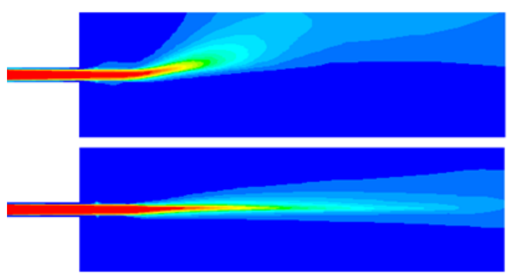

Figure 15 Temperature distribution along the vertical section. The force of gravity is directed downward

Figure 16 Zero temperature isosurface (side view)

The second model of the coaxial tube with the nozzle at an angle of 45°. The results of the study are shown in Fig. 15, 16.

At nozzle exit at 45° angle there is a reduction of isosurface zero temperature.

Model 3 represents the developed device of chimney system with intensification of incoming air heating by combustion products and additional heating from water coil. Fig. 17 shows the structure of flow along the chimney of mathematical modelling of Model 3 with additional air heating.

The conducted research allowed us to establish that the system of equations provides a sufficient degree of convergence of the results with the values obtained in the simulation. The results of the mathematical study showed the effectiveness of the proposed scheme. By means of ANSYS FLUENT software system it has been determined that the developed energy-efficient scheme of air supply into the furnace of a heat generator using combined heating increases the air temperature by 20-30%, which significantly improves the combustion process due to reduction of harmful emissions into the environment [6]. Study of various types of coaxial chimney systems allowed to determine the optimal parameters for dissipation of combustion products, taking into account maintaining the performance of the chimney system.

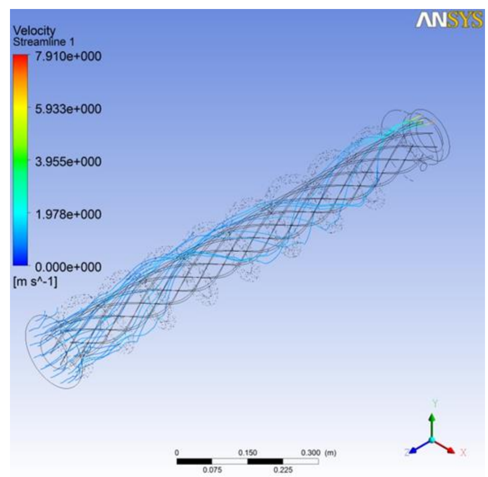

Figure 17 The structure of the swirling flow. Here and further, gravity is directed in the opposite direction to the Y axis.

5. CONCLUSION

Currently, the main direction of development of the energy sector is the search for ways to improve efficiency and energy conservation. Energy-saving solutions must take into account the impact of harmful emissions into the environment. The efficiency of small boilers is very strongly influenced by the environment and its climatic characteristics. The article presents a graph-analytical method of determining the amount of heat required for heating the combustion air and the additional consumption of natural gas of small capacity heat generators. Changes in air parameters lower the calorimetric temperature from 6...20 % and more. To provide the required thermal capacity additional heat is spent on heating the incoming air. As a result, fuel consumption increases or the required thermal energy is not provided at the normalized flow rate, which reduces the efficiency of the boiler. Also the incoming air with negative temperatures leads to the formation of condensate in the furnace, which increases soot formation during combustion of solid fuel.

Analysis of operation of small boilers showed that the greatest reduction of emissions into the environment is possible when considering a comprehensive approach from the furnace to the chimney. When operating natural gas-fired boilers in conditions of low outdoor air temperatures, a quality ratio of air and fuel is possible when preheating the air by utilizing the heat of combustion products. At work of boilers on solid fuel the most comfortable is the operation of boilers of long combustion. But for optimal operation with minimal emissions into the environment, it is necessary to clearly adhere to the required ratio of fuel and air. For operation in conditions of low outside air temperatures, it is necessary to provide a transition from the principle of top combustion to the classical combustion, to maintain the temperature at the supply line. The combustion product dispersion process depends directly on the shape and height of the chimney and the velocity of the combustion products. The flue gas dissipation has to be taken into account in the development of architectural and planning concepts and technical solutions for heat supply.

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