Ministry of Education and Science of Ukraine

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International Competition of
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BLACK SEA SCIENCE 2018

PROCEEDINGS

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Odessa National Academy of Food Technologies

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Міжнародний конкурс студентських наукових робіт

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DEVICE FOR CLEANING OF FLUE GASES FROM SULFUR OXIDES AND CARCINOGENIC RESIN

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Examines the problem of flue gas from the carcinogenic resin in enterprises that uses boilers. Carcinogenic substances present in flue gases causing cancer in humans are noted. The proposed use of a new innovative device for cleaning flue gases from carcinogenic resin, which will provide a significant reduction in air pollution in areas near industrial facilities with boiler systems. The scheme solutions of flue gas treatment plants and methods of purification, which given form the basis of their work.

Introduction

Serious influence on human health, vegetation and animals living in the field of flue gas emission from technological processes of a number of industrial enterprises is exerted by emission of harmful substances [1 – 4]. As a result, there is a need to control at the present level the content of these harmful emissions into the atmosphere [5, 6]. The content of sulfur, nitrogen and carbon oxides in the initial flue gases, which are formed during combustion of solid or liquid fuels, is a serious environmental threat. For example, chemical compounds such as sulfurous anhydride SO2 and sulfuric anhydride SO_3, nitrogen oxides NO, carbon oxides CO_2, when combined in the atmosphere with steam form acids $H2SO_3$, H_2SO_4, HNO_3, HNO_2, H_2CO_3 which cause harmful effects on human health, lead to the death of forests and fruit trees, reducing crop yields [7]. Carcinogenic resins have a serious impact on the environment [8]. They have the ability to accumulate in humans and animals, provoke chronic lung disease and also accumulate in plants [9]. The creation of new effective methods of gas purification is still an actual task [10].

The aim of the presented work is to modernize the filtration systems of flue gases by introducing into the filtration system new units, the use of which will allow cleaning at a higher quality level.

The results of the work are proposed to be used for the purification of flue gases from the combustion apparatus in heat and power industry.

Analysis of the modes of operation of the furnace of the boiler and especially the flue gases

With the development of industry and the increase of enterprises using boiler plants in production, the load on the environment is growing. The problem of creating more efficient methods of flue gas purification is becoming increasingly important. The largest amount of harmful emissions into the atmosphere occur when starting, changing the modes of robots and heating boilers. The composition of flue gases, depending on the fuel type or combustion mode include many different compounds. The combustion of organic fuel is accompanied by the release of thermal energy. In addition, as a result of chemical and physical reactions, smoke is released, which have various chemical compounds in their composition. Through uncontrolled release of combustion products into the atmosphere can be formed smog. This is observed during humid and windless weather. Oxides congenerous on suspended particles of water, forming a variety of acids.

Consider the mode of burning fuel in the boiler. During the initial stage, the temperature increases and carcinogenic resins are released from the fuel after reaching a certain value. Their release occurs until the temperature reaches a value when the resin begins to decay. Graphic representation of the combustion process is shown in Fig. 1. The line on the chart shows the dynamics of the growth of temperature in the boiler relative to

the time of the combustion process. The chart is divided into several zones, which are characterized by their temperature and exposure.

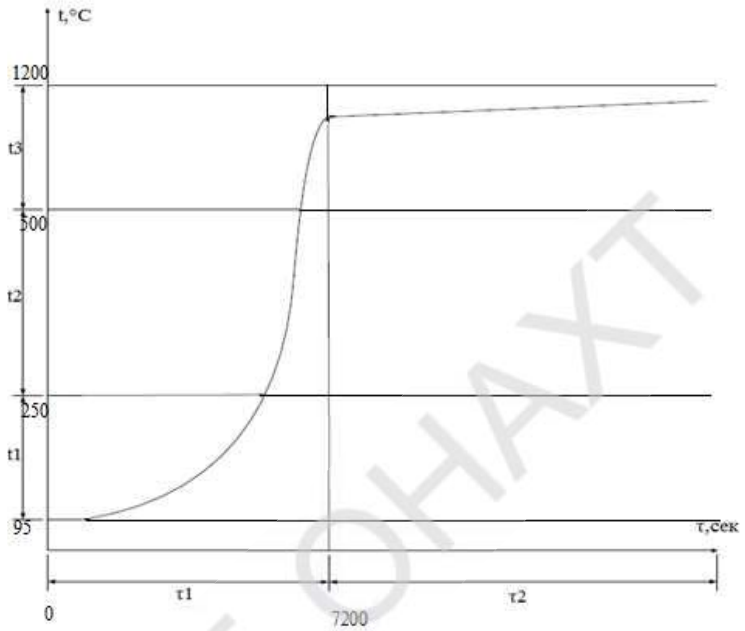

Fig. 1 Graph of kindling the furnace

Cleaning performed by operation of the proposed filter shall be performed in the first time zone and in the temperature period t1 and t2. Data for plotting taken from studies of start-up modes of the boiler. These data are averaged, as each boiler has its own individual ignition time, which depends on a large number of factors.

Schematic solutions for flue gas treatment plants

One of the known methods of flue gas purification is the condensation filter of flue gases. Condensing suction jet filter is designed for condensation of the carcinogenic tars, which are formed by firing the boilers in a mixture of low-quality coal fuels, as well as in transient modes. The required amount of refrigerant can be calculated using the created mathematical model for the processes occurring in the plant. On the chart, shown in Fig. 2, the flue gas temperature curves relative to refrigerant costs are given, calculated for different flow values.

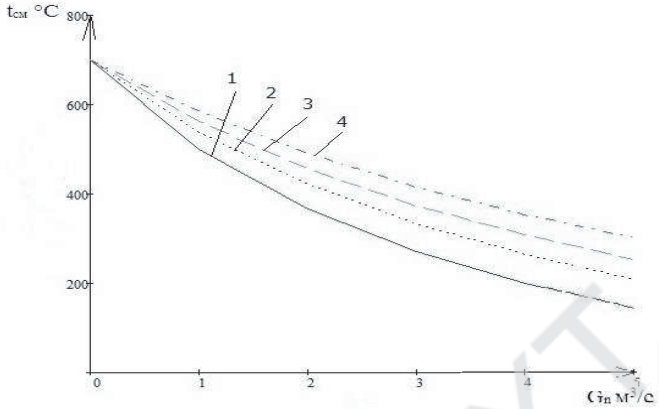

Figure 2 – Graph of temperature of the flue gas relative to the cost of the refrigerant: 1 – volumetric flow rate of flue gases of 4.05 m^3/s; 2 – volumetric flow rate of flue gases 5,248 m^3/s; 3 – volumetric flow rate of flue gases 6,286 m^3/s; 4 – volumetric flow rate of flue gases 7,662 m^3/s

At fig. 3 presents the scheme of installation for flue gas cleaning from tar carcinogenic [11]. Through this device passes the flue gas from the boiler furnace, which contains a carcinogen resin. Passing through the eductor, the gases are accelerated in the constriction, where a special chamber in the flow of introduced liquid refrigerant, which evaporates, lowers the temperature of the stream. Carcinogenic resin thus precipitated and removed in suspension with the flow in the removable tank, where the drops of the substance deposited on the walls. Next, the gas flow is displayed with the filter.

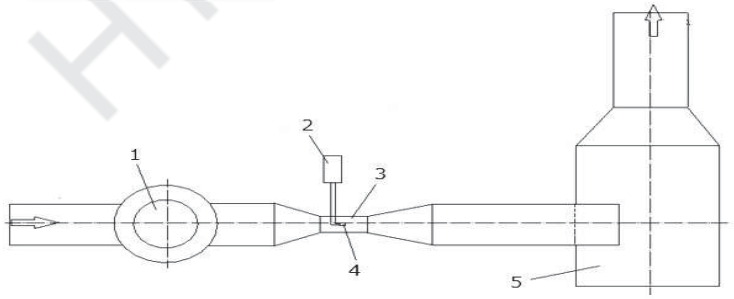

Figure 3. Scheme of installation for purification of flue gas from carcinogenic resins: 1- gas blower; 2-coolant supply; 3-mixing chamber; 4 – spray nozzle; 5 – liquid separator

At fig. 4 the improved scheme of installation of purification of flue gas is resulted. The flue gas flow through the nozzle 3 is fed to the mixing chamber 2, where the supercharger also serves 1 air from the environment at a speed of 10...20...20 m/s. the Mixing of ambient air with the flue gases is carried out to oxidize the oxides of the contaminants contained in the flue gas and reduce the temperature. The formed mixture at a speed of 10...15...15 m/s is served in the confuser 11 of the first HEE 4 accelerate to the speed of 60...70 ... 70 m / s. A liquid cooling agent (e.g. nitrogen) is injected into the stream through the first nozzle 6. As a result of contact with a fine-dispersed cooling agent, an instant mixing occurs with a decrease in the flow temperature to the starting temperature of the pollutant release reaction. The cooled stream is fed into the confuser 13 of the second heat exchanger-the ejector HEE 7, where it is accelerated to 70...80 ... 80 m / s, fed into the mixing chamber 14, where the stream through the nozzle 9 injected water.

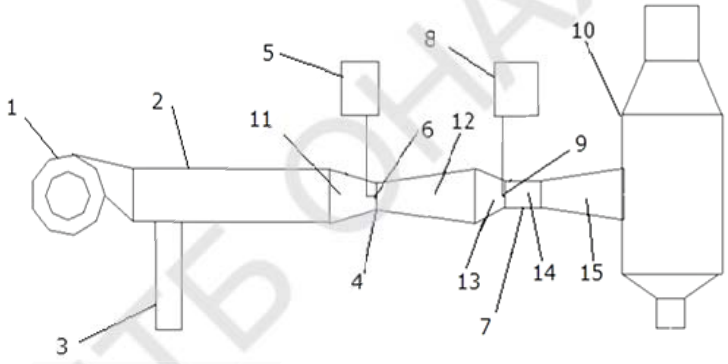

Figure 4. An Improved scheme of the installation for flue gas treatment: 1- gas blower; 2-mixing chamber; 3-a nozzle from the flue gas supply to the mixing chamber; 4-the first heat exchanger-ejector (HEE); 5-a container for the cooling agent; 6-the first nozzle; 7-the second heat exchanger-ejector; 8-a container for water; 9 – the second nozzle; 10-a liquid separator; 13-a confuser; 15-a diffuser; 14-a mixing chamber

Upon contact of the flow of flue gas, which contains oxides of pollutants, such as SO_3, CO_2, NO_2, fine sprayed water, the reaction occurs with the formation of acids whose molecules congenerous microparticles of dust, forming the nucleus:

$$SO_3+H_2O=H_2SO_4,$$

$$2NO_2+H_2O=HNO_3+HNO_2,$$
$$CO_2+H_2O=H_2CO_3.$$

Then the flow enters the liquid separator 10, where the acid condensate is separated and the flue gases are released into the environment.

The starting temperature of the hydration reaction (release of pollutants from flue gases) is 400...500 °C. As usual, the temperature of flue gas supply to the cleaning device is 600 ... 700 °C, i.e. much higher. Therefore, the proposed device provides for cooling of flue gases before cleaning in the previous cooling unit.

Schemes of devices for storage and supply of refrigerant are shown in Fig. 5 and Fig. 6.

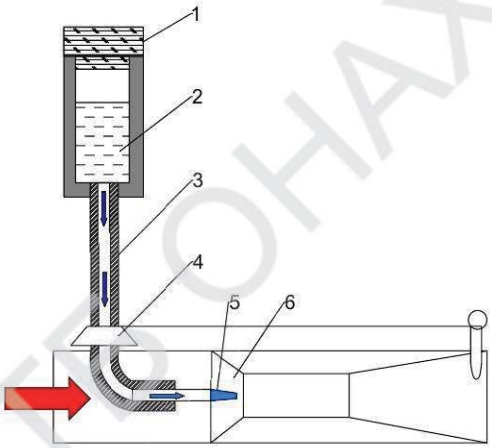

Figure 5. Diagram of the device for storing and handling refrigerant with a high vacuum cryogenic pipeline: 1-cover; 2-insulated container with liquid nitrogen; 3-high vacuum cryogenic pipeline; 4 – shut-off and regulating device; 5 – nozzle; 6 – ejector-heat exchanger

These devices require special attention because storing and pumping liquid refrigerant requires some technical modifications of the pipeline. To ensure the stable operation of this scheme, a reliable method of regulating the supply of the working fluid is needed. Conventional shut-off valves are not suitable for such purposes. A special shut-off valve is required, designed for working environments such as low boiling point liquid refrigerants.

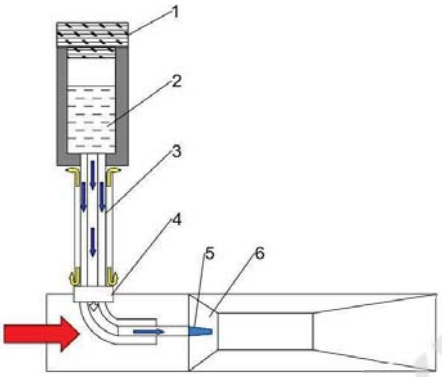

Figure 6. Diagram of the device for storing and handling refrigerant:
1-cover; 2-insulated container with liquid nitrogen;
3 – cryogenic overflow device; 4 – shut-off and regulating device;
5 – nozzle; 6 – ejector-heat exchanger

It is also envisaged to purify flue gases from sulfur oxides. It should be noted that the modes of operation of the filtration system and cleaning methods will vary, as they are used at different stages of the boiler. So, flue gases cleaning from resins is carried out at the initial stage of the boiler operation, and oxides cleaning should take place during the active mode of the boiler operation.

Discussion of the advantages of a new method of gas purification

In comparison with other methods of flue gas purification, the proposed devices are characterized by a relatively simple technical execution, so that their reliability is significantly increased. In this case, the most suitable contact heat exchanger due to the fact that it has a developed heat exchange surface. Condensation on droplets of water-sprayed oxides of pollutants, such as SO_3, CO_2, NO_2, followed by the formation of acids, followed by their release when using inexpensive and non-deficient materials is an effective way of purification of flue gases, which can be used in thermal power plants using coal as fuel, liquid fuel or a mixture thereof.

Summary

The application of the proposed method of flue gas purification will almost completely eliminate the flow of flue gases from pollutants from the group of carcinogens. This need arises due to the transition to low-quality fuels and a high percentage of emissions at the time of transitional operation of boiler plants.

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