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USE OF WATER CONDENSATE AT IMPLEMENTATION OF HEAT-RECOVERY TECHNOLOGIES IN THE GAS-FIRED BOILER PLANTS

Summary. *The areas of useful use or the technology of safe removal to the sewer network of chemically aggressive water condensate formed during deep cooling of waste gases at the operation of condensation heat-recovery units of gas-fired boilers are given.*

Key words: *waste gases, dew point temperature, condensation formation, heat-recovery technologies, exhaust-gases, decarbonization.*

One of the effective and economically justified ways of increasing the thermal and environmental efficiency of gas-fired boiler units is the deep heat-recovery of the heat of its waste gases – below the dew point of water vapor [1-9]. Under such conditions, a chemically aggressive water condensate is formed due to the fact that upon contact with water, carbon and nitrogen oxides as a result of a chemical reaction turn into carbonic H_2CO_3, nitrous HNO_2 and nitric HNO_3 acids. Therefore, the problem of its further beneficial use or safe removal to the sewage network is relevant. The obtained water condensate under the conditions of combustion in natural gas boiler units is characterized by a hydrogen pH within the range of 3 ÷ 6 and practically zero hardness. This indicates that it can be usefully used (Fig. 1) for the needs of the boiler house (for washing boilers or in chemical water treatment systems) or for other technological processes outside the boiler house (for laundries, greenhouses, swimming pools, etc.).

If it is necessary to divert such condensate to the sewage system, it should be taken into account that condensate drainage to wastewater is possible only if its acidity is reduced to acceptable limits [10; 11]. This is required to protect the sewage network and treatment facilities from premature wear and tear and to prevent the death of bacteria used at aeration stations for wastewater treatment. Therefore, draining the condensate to the sewage system requires mandatory preliminary preparation by means of decarbonization.

Neutralization (decarbonization) of condensate is necessary (see Fig. 1) in the following situations:

1) In case of impossibility of beneficial use and forced discharge to the sewer network;

2) If the condensate is used to feed heat networks under conditions of significant acidity of raw water for chemical water treatment.

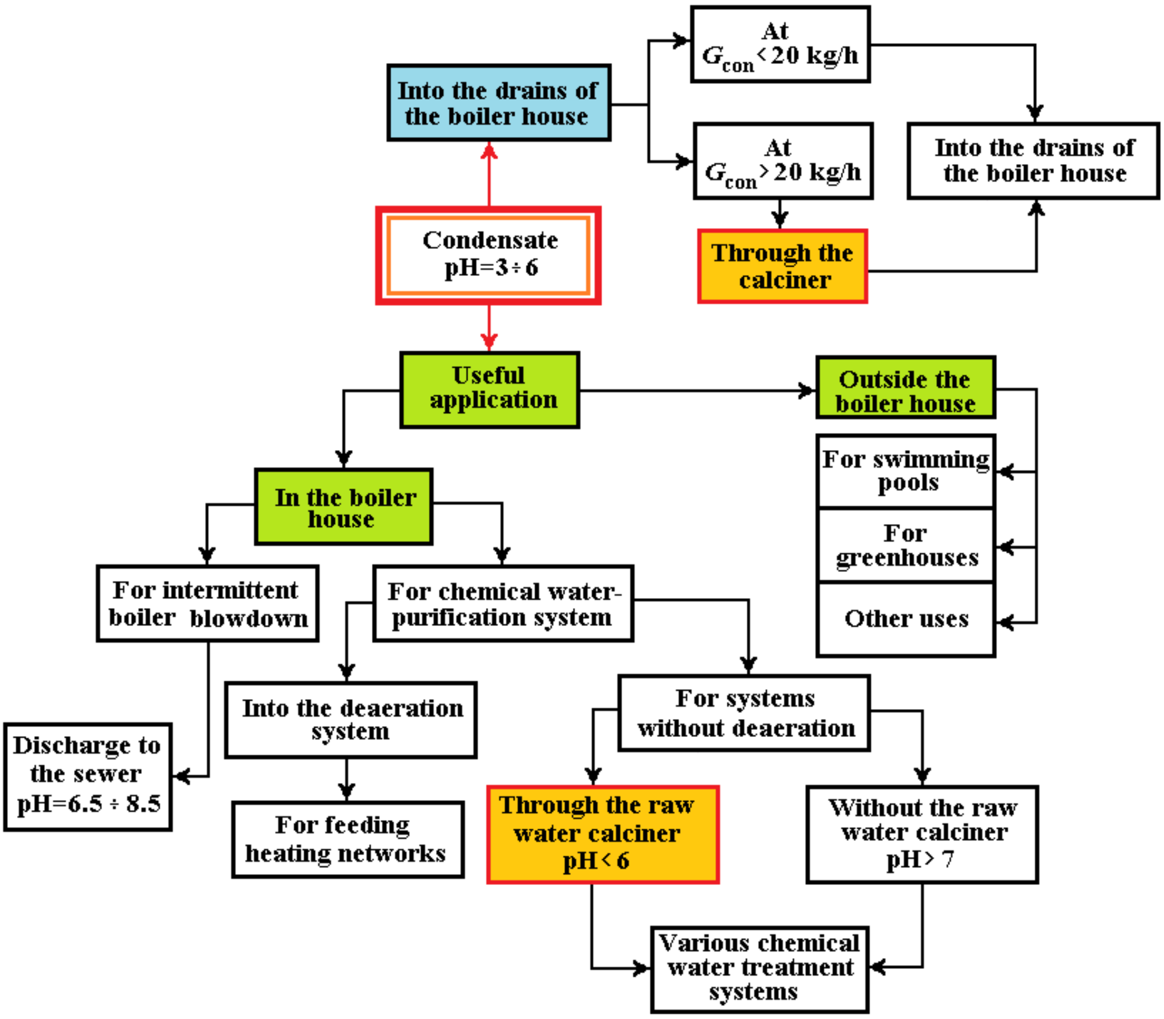

Fig. 1. Directions for using chemically aggressive water condensate in the boiler house or outside of it

In Ukraine, the most common are decarbonization by degassing by the contact method, chemical and by passing condensate through a filter with calcium carbonate (marble crumb, lime) [5].

Decarbonization by degassing by the contact method requires the installation of a fan or exhauster to blow air through the decarbonizer. This creates an additional load on the exhauster and the exhaust-gas tract. In order to obtain a neutral pH reaction of the condensate, it is necessary to carry out a deep removal of carbon dioxide, which may require significant air consumption. That is, such a method requires large energy costs. Due to the fact that the air from the decarbonizer enters the chimney, the temperature of the flue gases and the draft of the chimney decrease. Another disadvantage of this neutralization method is additional greenhouse gas emissions.

Chemical decarbonization is carried out by adding a chemical neutralizing solution to the condensate. For this, condensate enters a special tank of a certain volume. Then, with the help of a dosing pump, the necessary amount of neutralizing solution, which contains lime, ammonium carbonate, etc., is added to the tank with condensate. This process is easily automated. For this, appropriate capital investments are required for the purchase of a pump, dispenser and other components of the automation system. Also, chemical decarbonization of condensate can be implemented under the conditions of adding raw water to it, which is used for chemical water treatment. Most natural waters contain carbonic acid salts, which have buffering properties. Therefore, their pH usually ranges from 7 to 7.5, due to the fact that HCO_3 ions prevent CO_2 from significantly lowering the pH of the water. To implement this process, installation of special neutralizing equipment is not required.

Decarbonization by contacting the condensate with a granular filter (marble crumb) occurs due to a chemical reaction between free calcium Ca contained in the marble crumb and carbonic acid H_2CO_3, resulting in the formation of an insoluble compound $CaCO_3$. Under these conditions, the neutralization of chemically aggressive condensate to the required normative values of the hydrogen index (pH = 6.5 ÷ 8.5) is ensured in accordance with [10]. This method of neutralization is the simplest of the considered methods of decarbonization of water condensate and is economically feasible due to the low cost of the filter material and its availability. Also, the advantage of the equipment with a granular filter is its compactness and ease of installation directly to the nozzle of the condensate outlet from the heat-recovery unit. It is not necessary to use a special tank to collect the resulting condensate. It is recommended to replace the filter material from marble crumb with a new one after 3 ÷ 4 months of operation of the decarbonizer

Conclusions.

1. For gas-fired boiler units at cooling its waste gases below the dew point temperature in condensing heat exchangers, additional measures should be applied for possible beneficial use or safe removal of the chemically aggressive condensate formed.

2. If there is a need to neutralize acidic condensate, there are effective methods and ways of its decarbonation, among which the simplest is the decarbonization method by contacting the condensate with a granular filter based on calcium carbonate.

References

1. Fialko N. M., Navrodska R. O., Gnedash G. O., Presich G. O., Shevchuk S. I. Study of Heat Recovery Systems for Heating and Moisturing Combustion Air of Boiler Units. *Nauka innov.* 2020. V. 16, No. 2. P. 47-53. doi: https://doi.org/10.15407/scin16.03.047
2. Fialko N. M., Navrodska R. O., Shevchuk S. I., Gnedash G. O., Glushak O. Y. Reduction of moisture content of exhaust gases in condensing heat-recovery exchangers of the boiler plants. *Scientific Bulletin of UNFU.* 2019. 29(8). P. 116-119. doi: https://doi.org/10.36930/40290821
3. Fialko N. M., Presich G. A., Gnedash G. A., Shevchuk S. I., Dashkovska I. L. Increase the efficiency of complex heatrecovery systems for heating and humidifying of blown air of gasfired boilers. *Industrial Heat Engineering.* 2018. 40(3). P. 38-45. doi: https://doi.org/10.31472/ihe.3.2018.06
4. Fialko N. M., Gnedash G. O., Navrodska R. O., Presich G. O., Shevchuk S. I. Improving the efficiency of complex heat-recovery systems for gas-fired boiler installations. *Scientific Bulletin of UNFU.* 2019. 29(6). P. 79-82. doi: https://doi.org/10.15421/40290616

5. Efimov A. V., Goncharenko A. L., Goncharenko L. V., Esipenko T. A. Sovremennye tekhnologii glubokogo okhlazhdeniia produktov sgoraniia topliva v kotelnykh ustanovkakh, ikh problemy i puti resheniia. Kharkiv: Kharkiv Polytechnic Institute. 2017. URL: http://repository.kpi.kharkov.ua/handle/KhPI-Press/32826 (date of access: 16.08.2023)
6. Fialko N., Presich G., Navrodska R., Gnedash G. Ecological efficiency of combined heat recovery systems waste of exhaust gases for boiler plant. *Bulletin of Lviv* Polytechnic *National University. The theory and practice of construction*. 2013. 755. P. 429-434. URL: http://ena.lp.edu.ua:8080/handle/ntb/22345 (date of access: 07.08.2023)
7. Fialko N., Navrodska R., Ulewicz M., Gnedash G., Alioshko S., Shevcuk S. Environmental aspects of heat recovery systems of boiler plants. In *E3S Web of Conferences*. 2019. Vol. 100. P. 00015. EDP Sciences. doi: https://doi.org/10.1051/e3sconf/201910000015
8. Fialko N. M., Navrodska R. O., Shevchuk S. I., Gnedash G. O. The environmental reliability of gas-fired boiler units by applying modern heat-recovery technologies. *Scientific Bulletin of National Mining University*. 2020. 2. P. 96-100. doi: https://doi.org/10.33271/nvngu/2020-2/096
9. Navrodska R., Fialko N., Presich G., Gnedash G., Alioshko S., Shevcuk S. Reducing nitrogen oxide emissions in boilers at moistening of blowing air in heat recovery systems. In *E3S Web of Conferences.* 2019. Vol. 100. P. 00055. EDP Sciences. doi: https://doi.org/10.1051/e3sconf/201910000055
10. On approval of the rules of sewage reception to centralized drainage systems and the procedure for determining the size of the charge for over-discharge wastewater to centralized drainage systems: order of the Ministry of Regional Development of Ukraine from 01.12.2017. URL: https://zakon.rada.gov.ua/go/z0056-18 (date of access: 16.08.2023)

11. Burger H., Boehle W. Specification sheet ATV-A 251: Energy-saving high-efficiency boiler systems and condensation water removal; Arbeitsblatt ATV-A 251 schafft Klarheit: Energiesparende Brennwertanlagen und Kondenswasserableitung. *Waermetechnik-Versorgungstechnik*. 2000. 45. URL: https://www.osti.gov/etdeweb/biblio/20087888 (date of access: 07.08.2023)