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PURIFICATION OF INTERNAL AIR OF BUILDINGS FROM ORGANIC PRODUCTS OF HUMAN METABOLISM

ОЧИСТКА ВНУТРЕННЕГО ВОЗДУХА ПОМЕЩЕНИЙ ОТ ПРОДУКТОВ МЕТАБОЛИЗМА ЧЕЛОВЕКА

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Abstract. *When there are people in the room, a large amount of metabolic products enters the air of this room. Many of these substances pose a significant risk to human health. In order to reduce energy consumption in air conditioning systems, it is advisable to clean the recirculated air from the products of human metabolism. Partial purification of recirculated air can be carried out in surface coolers with condensation of water vapor.*

Keywords: human metabolism products, air purification, surface cooler, water vapor condensation

Introduction. The reduction of energy consumption in air conditioning systems is based on an increase in the degree of recirculation of indoor air [1]. This is especially important in countries with hot climates. The amount of recirculated air is determined based on the allowable concentration of carbon dioxide (CO_2) in the room in accordance with the requirements [2].

The following products of metabolism were found [3] in the presence of people in the room: isoprene, methanol, acetone, acetic acid, 4-oxopentanal (4-OP 6-methyl -5-hepten-2-one (6-MHO) and etc. These products of human metabolism are absorbed by water in the contact air cooling apparatus. There is partial purification of the recirculated air from the products of metabolism. It requires studying the absorption of metabolism products by water.

Research tasks. Explore the effectiveness of air purification from organic substances in the water vapor condensate in the surface cooler

Method. It is more convenient to carry out studies on the absorption of organic substances from air by water in surface coolers during the condensation of water vapor on heat-exchange surfaces. Scheme of the stand for the study of the absorption of organic substances matter by water vapor condensate is shown in Figure 1.

Research stand is made of an open wind tunnel type. The fan provides air flow up to 800 m^3/h (it is not shown in Figure 1). The stand consists of a block of heating and moistening of air, organic substances dispenser, block mixing air with organic substances and surface air cooler. Devices of the stand provide measurements of: air flow and water vapor condensate; air and water vapor condensate temperatures, air humidity before and after the surface cooler; organic substances concentrations in the air and in the condensate. Placement in the surface cooler provided countercurrent movement of air and condensate in it.

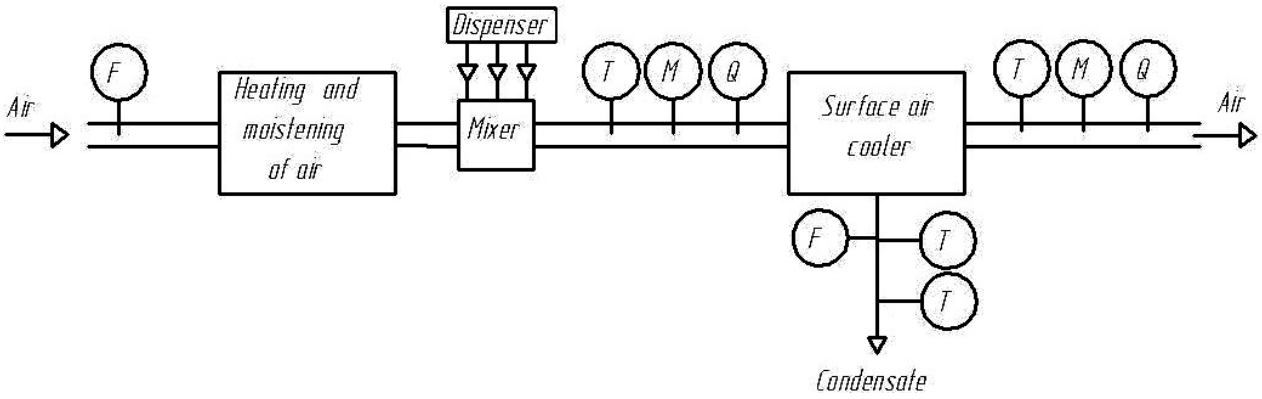

Figure 1. The scheme of the research stand.

Acetone, benzene and ethyl acetate are accepted as representatives of the main groups of substances identified in indoor air [3].

The efficiency of the absorption process is determined by the absorption factor, which is proportional surface air cooler to the ratio of the flow rates of the phases and the conditions of stability of the interface [4]. This allows us to conclude that the efficiency of water absorption of organic matter from the air t depends on the stability criterion of the gas-liquid flow. The criterion for the stability of the gas flow is determined by the following expression [5]:

$$K = {w_g \bullet \rho_g^{0,59}} \Big/ {[\sigma \bullet g \bullet (\rho_l - \rho_g)]^{0,25}}, \quad (1)$$

where: w_g - the air velocity in the frontal section of the surface cooler; ρ_g and ρ_l - density of air and water, respectively; σ - water surface tension; g - gravity acceleration.

The purification efficiency is calculated as follows:

$$E = {(C_{g1} - C_{g2})} \Big/ {C_{g1}}, \quad (2)$$

where: C_{g1} and C_{g2} - the concentration of organic substance in the air before and after the surface cooler, respectively.

The reliability of the measurement results was estimated based on the mass balance of the substance

$$G_g \bullet (C_{g1} - C_{g2}) \approx G_l \bullet C_l, \quad (3)$$

where: G_g and G_l - the mass flow of air and condensate, respectively; C_l - concentration of organic substance in the condensate.

The results of measurements with an imbalance of less than 5% were taken for further analysis of the purification efficiency.

The research results. The research results on the effects of absorption of acetone, benzene and ethyl acetate in the range of changing the value of the stability criterion for gas-liquid mixture from 0,5 to 1,5 (change in air velocity in the front section of the cooler from 1,0 to 3,4 m/s) shown in Figure 2.

Data (Figure 2) on the purification efficiency obtained for concentration ranges: acetone - from 6 to 33 mg/m^3, benzene - from 2 to 14 mg/ m^3, ethyl acetate - from 2 to 20 mg/m^3. The air temperature at the inlet to the cooler was 27…32 ^{o}C. The

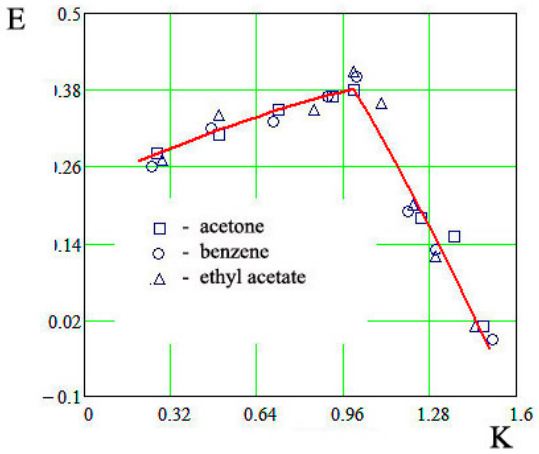

Figure 2. The effectiveness of air purification from a mixture of organic substances in the condensation of water vapor on the surfaces of the cooler (C_{Σ}≈35 mg/m^3).

amount of condensed water vapor ranged from 0,008 to 0,010 kg/kg air. The depth of the heat exchanger was 0.5 m.

Analysis of the data in Figure 2 shows that with the values of the criterion for the stability of a gas-liquid mixture, the efficiency of air purification by condensation of water vapor from organic substances sharply decreases. This is explained by the fact that in the channels of the heat-exchange surface the mode of motion of the gas-liquid flow changes.

The dependence of the efficiency of air purification on the amount of condensed water vapor is shown in Figure 3

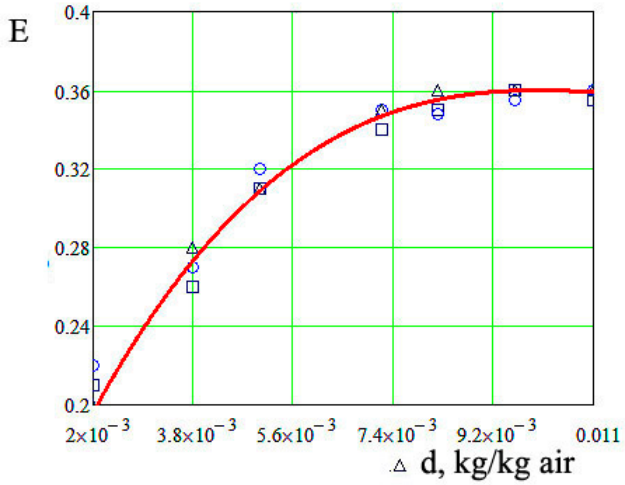

Figure 3. The dependence of the efficiency of air purification on the amount of condensed water vapor at C_{Σ}≈20 mg/m^3. The legend corresponds to Figure 2.

The data of Figure 3 shows that the effectiveness of air purification from organic substances increases with an increase in the amount of condensed water vapor from 0.002 to 0.008 kg / kg air. A further increase in the amount of water vapor does not lead to a significant increase in cleaning efficiency.

The air purification efficiency is 0,36…0,40 in the range of changes in the the amount of condensed water vapor from 0.008 to 0.010 kg / kg air and in the range

of changes in the total concentration of organic substances from 5 to 35 mg/m^3.

Conclusion. The conditions for purification indoor air in surface cooler from organic substances emitted by man in the process of metabolism were considered. Regression dependencies are obtained for calculating the efficiency of air purification during condensation of water vapor in a surface cooler. It has been established that the efficiency of air purification from organic products of human metabolism can reach 40% with the condensation of water vapor in the amount of 0,008…0,010 kg /kg air in a surface cooler.

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Аннотация. При присутствии в комнате людей в эту комнату попадает большое количество продуктов метаболизма человека. Многие из этих веществ представляют значительный риск для здоровья человека. Чтобы снизить потребление энергии в системах кондиционирования воздуха, целесообразно очищать рециркуляционный воздух от продуктов человеческого метаболизма. Частичная очистка рециркуляционного воздуха может проводиться в поверхностных охладителях с конденсацией водяного пара.

Ключевые слова: *продукты метаболизма человека, очистка воздуха, поверхностный охладитель, конденсация водяного пара.*