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WATER AND GLYCOL COOLANTS IN THE AUTONOMOUS HEAT SUPPLY

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ABSTRACT

The solution to the problem of defrosting in the autonomous systems of heat supply in cases of an accidental power outage is often solved by replacing the water in the "freezing" of heat carriers, which include the water-glycol mixture. However, it must be borne in mind that the water-glycol fluids can lead to significant violations of the mode of operation of the heating system, which may lead to a decrease of heat transfer and the ingress of air into the system, as well as boiler malfunction that could lead to a decrease in performance or damage to the heating surfaces due to the formation of domestic deposits. In this study reviewed and analysed thermal and hydraulic features of water-glycol (WG), water-ethylene-glycol (WEG) and water-propylene-glycol (WPG) coolants autonomous heating systems of various types. Analysed the cost comparison, coolant system pressure losses and the principle choice of the volume of the expansion vessel.

Keywords: water, glycol, coolant, density, scale, heat.

1. INTRODUCTION

At present, any heating system is focused on coolant. As the perfect option does not exist, you should choose one that provides energy with minimal losses maximum safety and durability of the functioning of the equipment.

Ability to accumulate water when heated and when cooling a large amount of heat is a good coolant. It has good fluidity and easily circulating heating system. It is important that we are talking about eco-friendly stuff. Consequently, possible leakage will not cause a catastrophe on the scale of the individual home. But! All these advantages are offset by one major drawback-the possibility of freezing water in the system and, as a consequence, the conclusion of the last (House with off, but filled with winter heating system does not leave). Another drawback can be considered the need to change the chemical composition of water before use for heating. In addition, still appears the corrosion of all metal parts of the heating system.

Most consumers for heating private houses, autonomous systems of high-rise buildings and rooms used for household and industrial use choose glycolic ice-free liquid. These chemicals have almost the perfect formula, providing for a powerful range of useful exploitation properties. But with each heat for heating systems have a number of peculiarities, deficiencies that need to be taken into account when used in each case [1].

The consumer's desire to protect from freezing heat supply system is often implemented using transfer it with water to the "unfreezing" coolant [2]. Mostly seen quite a wide range of water-glycol (WG), water-ethylene-glycol (WEG) and water-propylene-glycol (WPG) coolants with integrated coolant additives that provide stability properties, mode of operation without scale, low corrosion. Moving offline heat supply systems on water-glycol heat transfer leads to serious violations of operating mode of heating systems, which are expressed in the lowering of heat transfer and air ingress into the system, as well as malfunctions of the boiler, which is accompanied by a decrease in performance or damage to the heating surfaces due to the formation of domestic deposits [3].

2. METHOD

Previously on several occasions examined the impact of higher in comparison with water for viscosity, density of WG, lesser heat capacity and a number of other factors on the hydraulic system operation mode. Analyzed comparing costs, coolant system pressure losses and the principle choice of the expansion tank volume in the heating system for WEG Dixis30 and Dixis65 in [4]. It should be noted that the scientific and technical literature was drafted an incorrect conclusion about the need to increase the calculated pressure circulating pumps in the heating system when you use the WEG Dixis30 to 54% and 72% to Dixis65, due to the fact that the increase in hydraulic resistance [5] in the system is evaluated solely growth of friction resistance along the length of the hydraulically smooth pipe. Total losses in the hydraulic system consists of friction losses ΔP_{fr} and losses in local resistances ΔP_{loc} that are in most cases for pumping systems the main component of hydraulic losses

$$\Delta P_t = \Delta P_{fr} + \Delta P_{loc} \tag{1}$$

$$\Delta P_{loc} = \sum_{i=1}^{m} \xi_i \frac{\rho \omega_i^2}{2}.$$

In this equation the coefficient of local hydraulic resistance ξ_i [6], as well as the resistance coefficient of friction depends on the Reynolds number (Re):

$$\xi_i = 0.184\,\mathrm{Re}^{-0.2} \tag{2}$$

that is for the coolant flow conditions, with the corresponding increase in flow rate and velocity (w) at

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1.08 times (due to the reduction of heat WEG) increase in pressure loss in local resistances in the transition from water on WG (crystallization -30°C) is [7]:

for WEG: $\frac{\Delta P_{\text{locT}}}{\Delta P_{\text{locB}}} = (\frac{\omega_{\text{T}}}{\omega_{\text{B}}})^{1.8} \times (\frac{v_{\text{T}}}{v_{\text{B}}})^{0.2} = 1.48$

for WPG: $\frac{\Delta P_{\text{locT}}}{\Delta P_{locB}} = (\frac{\omega_{\text{T}}}{\omega_{\text{B}}})^{1.8} \times (\frac{v_{\text{T}}}{v_{\text{B}}})^{0.2} = 1.52$

3. RESULTS

So, with the increasing pressure losses in local resistances increased hydraulic loss in heat supply system for WEG (Dixis-LP) at 48% and 52% at WPG [8].

It should be noted not so much on the principle of work of WG in the heating system (where the effects of using WG are not so significant), but rather the consequences of the application of this system in the boiler of WG. The key difference is that heat transfer in heating appliances and pipes of the heating system the maximum thermal resistance, Watts, takes place on the external surface (with air) [9]:

$$Q = kF\Delta t = \frac{1}{1/\alpha_{\text{в}} + \sum \delta_i / \lambda_i + 1/\alpha_{\text{н}}} F\Delta t \qquad (3)$$

F - convection, m; Δt - difference between the temperature of the coolant and air, K; k - heat transfer coefficient, W/(m^2·K); δ,λ - the thickness of the separating wall, m, and its coefficient of thermal conductivity, W / (m·K) (for metal heaters δ/λ has low values) [10]; $\alpha_{\text{в}}$ - heat transfer coefficient on the inner surface by the coolant (water ~ 400 ... 600 W / (m^2·K)); $\alpha_{\text{н}}$ - generalized heat transfer coefficient, averaged across the external surface element heating system by natural convection air (the value of 20 W/(m^2·K)).

Due to the fact that internal heat transfer coefficient is significantly $\alpha_{\text{в}}$ larger than the corresponding value, even a significant deterioration of heat exchange $\alpha_{\text{н}}$ on the inner surface (reduction $\alpha_{\text{в}}$ in two times and more) will not seriously impact the heat transfer through the heating system (no more than 1-2%) [11].

Quite different is the case of the heating surfaces of boilers for heating systems, where individual plots of heating surfaces in the furnace have a fairly large unit thermal stresses, q_F W/m^2, both from the side of the flue gases (often developed finned surface [12]), and given to the internal surface cooled heat. For example (Figure-1), for wall boiler Saunier Duval SD-235 full geometrical surface heat exchanger flow is F = 4.8 m^2, with smooth external surface heat exchanger pipe F_t = 0.12 m^2. Consequently, boiler operation at rated power Q = 35 kW is characterized by medium-sized bulk thermal voltage complete heating surface:

$$q_F = Q / F = 7111 \text{ W/m}^2 \qquad (4)$$

and a similar amount in calculating on a smooth surface cooled heat exchanger tubes will be equal to:

$$q_{F_t} = Q / F_t = 290000 \text{ W/m}^2 \qquad (5)$$

Such significant heat flux for heat exchanger tubes lead to large temperature variations but the thickness of the wall between a wall and the flow of coolant, which depend on the cooling conditions [13]. Than better cooling, i.e. the higher the value of the coefficient of heat transfer from wall to heat, the lower the temperature of the metal wall in similar thermal load [14]. Therefore, when translating the boiler on WG must first and foremost analyse changing conditions of heat exchange surface on the inner side of the boiler, which perceives the warmth. The equation is used for comparative assessment of similarity for turbulent flow (Re > 10000) [15] liquid in smooth pipes:

$$\text{Nu} = 0.021\text{Re}^{0.8}\,\text{Pr}^{0.4}(\text{Pr}/\text{Pr}_w)^{0.25} \qquad (6)$$

which defines the size of accepted equivalent diameter d_e for pivotal temperature is the average temperature of the liquid [16]:

$\text{Nu} = \frac{\alpha d_e}{\lambda_l}$ - Nusselt number; $\text{Re} = \frac{\omega d_e}{v}$ - Reynolds number; $\text{Pr} = \frac{vc\rho}{\lambda_l}$ - Prandtl number.

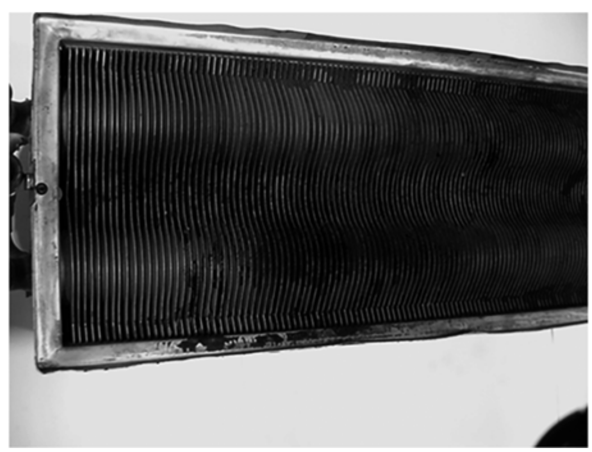

Figure-1. Type of the combined double-circuit heat exchange device of a flowing gas boiler.

Identical conditions of flow fluids[17](the same volumetric flow rate and flow velocity) in a similar boiler

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heating surfaces, you can get the relative values of the desired values:

$$\frac{\alpha_T}{\alpha_B} = (\frac{\lambda_T}{\lambda_B})^{0.6} \times (\frac{\nu_B}{\nu_T})^{0.4} \times (\frac{\rho_T}{\rho_B})^{0.4}. \quad (7)$$

4. CONCLUSIONS

The advantages of glycol coolants are insurance system from freezing, good thermal properties, low salt deposits and scale, the average cost. The disadvantages include: ethylene glycol is toxic, narcotic effect. In a body absorbed quickly. The degree of harm that ethylene glycol causes man depends on the amount of poison, ways of penetration and the individual State of the organism. Ingestion happens develops pulmonary oedema, congestive heart failure. Experts call the different figures of a lethal dose of the substance: 5 mg per kg of body weight; 50-500 mg per person. Mortality in acute poisoning is higher by more than 50% ethylene glycol can penetrate through the skin and into the body by inhalation. It is therefore very dangerous ethylene-glycol apply coolant in open systems-evaporation spread indoors; in combi boilers can happen to mix toxic coolant into the hot water. With prolonged exposure may have chronic poisoning with the defeat of the vital organs (blood vessels, kidneys, nervous system). The first signs of poisoning are depressed mood and lethargy. Especially it is worth remembering that ethylene glycol has no unpleasant odour and has a sweetish taste, which is an increased danger to children and animals, in the case of leaks coolant from the system. Heat transfer based on ethylene glycol is an environmental hazard. When handling the product should be deleted it is spilling on the ground and in space. Dispersants in a residential building, floor boards, tiles, insulation, impregnated ethylene-glycol coolant must be replaced. Contaminated soils shall be subject to seizure. The waste of ethylene glycol-based coolant should be collected and submitted for recycling. It is forbidden to dispose the waste in open ground and into sewers. The waste of ethylene glycol-based coolant has a high viscosity at low temperatures. It should be noted that the glycol coolants are not allowed if the heating system uses galvanised pipes. Therefore, one shouldweigh the pros and cons of using water and water-glycol coolants in the heating system of a particular object.

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