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EXPERIMENTAL METHOD OF STUDYING THE LIMIT STATE OF THE HEAT EXCHANGE SURFACE COVERED BY A CAPILLARY-POROUS MEDIUM

Abstract. Capillary-porous systems have high intensity, high heat transfer ability, reliability, compactness. The results of calculations and experiments showed that the maximum thickness of the particles that break off under the action of compression forces for coatings from granite is $(0{,}25 \div 0{,}3) \cdot 10^{-2}$ m. Sections of compression curves that determine the separation of particles with dimensions of more than $0{,}3 \cdot 10^{-2}$ m for large heat fluxes and short feed times, are screened by the melting curve, and in the case of small heat fluxes and time intervals, the expansion curve. The research is aimed at creating porous coatings in cooling systems from well – and poorly conductive materials.

Keywords: heat transfer crisis; capillary-porous structure; heat and power installations, cooling systems.

Introduction. Successful use of capillary-porous materials in engineering attracted many researchers and inventors to create different devices on their basis. The intensity of heat-eliminating systems and the forcing of processes taking place therein increased [1-3]. In addition to cooling systems, the use of porous materials allowed the creation of units which addressed the problems of explosion safety, labor protection and durability [4, 6]. This was facilitated by the ability to control evaporation processes due to excess fluid in pores and capillary structures, formed by the combined action of capillary and mass forces [7-9].

In thermal power plants (TPPs), capillary-porous materials are used to cool highly-forced detonation burner units [3], to create steam coolers in steam boilers [9], oil coolers that prevent oil from entering cooling water and water from entering the bearing system [10] and labyrinth seals [11], and are used in other devices [10]. The main areas of practical application of capillary-porous systems are presented in [3, 5, 8-11].

Equipment and technological processes in the energy sector should be introduced from the ecological and economic positions primarily. The proposed development of capillary-porous systems will facilitate the implementation of processes, significantly improving and preserving the natural environment.

The main advantages of capillary-porous systems include high intensity, high heat transport ability, reliability, compactness, simplicity in manufacture and operation. These systems improve operational and technological performance and have low capital and operating costs. Based on the study of capillary-porous systems, new technical solutions have been developed to improve the performance characteristics of the thermal power plant in relation to the powerful power units of combined heat and power plants.

The authors of [12] carry out a comparative analysis of methods for calculating the heat transfer, based on the water boiling with underheating in vertical channels, and they consider that the hot spot corrosion of fuel element claddings of nuclear reactor fuel elements is similar to the capillary-porous structure [13, 14]. However, no studies of heat transfer through a regular structured surface have been carried out.

According to the authors' opinion [15,16], surface boiling on porous surfaces can influence the development of corrosion due to the erosive action on the heat exchange surface, when the bubbles of steam fall in an underheated liquid. Therefore, it is required to investigate the evaporation of liquid in capillary-porous structures in the field of capillary and mass forces, taking into account the velocity and underheating, which are formed by excess fluid.

An estimated intensity of heat transfer for liquid boiling in a large volume and thin films on a smooth surface showed equal possibilities [12-14] at high thermal flow and higher heat transfer parameters than that in systems with a capillary-porous coating [15, 16]. It is required to carry out investigations of the heat transfer capabilities of capillary-porous coatings operating in the field of capillary and mass forces, and to establish ultimate (critical) load values leading to the destruction of the heating surfaces. Figure 1 presents a method for studying capillary-porous systems for various elements of power plants. The systems differ in the fact that they have predominantly a gravitational fluid supply and occupy an intermediate position between thin-film evaporators and porous evaporators with a predominantly capillary fluid supply (heat pipes) in terms of the intensity of heat transfer. Therefore, such systems should be identified in a separate class of heat-eliminating systems. The performed researches make it possible to give recommendations on the selection of the heating-and-cooling medium, take into account the type of its circulation, determine the geometry and material of apparatuses and heat exchange intensifiers, taking into account the conditions and orientations of the system operation under pressure or underpressure, the energy supply and type and the system orientation. Generalization of the experimental results and calculation procedure for heat and mass transfer in capillary-porous systems in accordance with Figure 1, are presented in [17-21].

Model of the capillary-porous structure of the cooling system. Figure 1 shows the model of a capillary-porous coating applied to the coolable surface of a heat-loaded element of power plants. At the onset of the boiling crisis, the critical state of the heating surface arises, and the latter is destroyed along with the coatings. Such a scheme allows to make a model of fissures of brittle coatings and plastic porous structures.

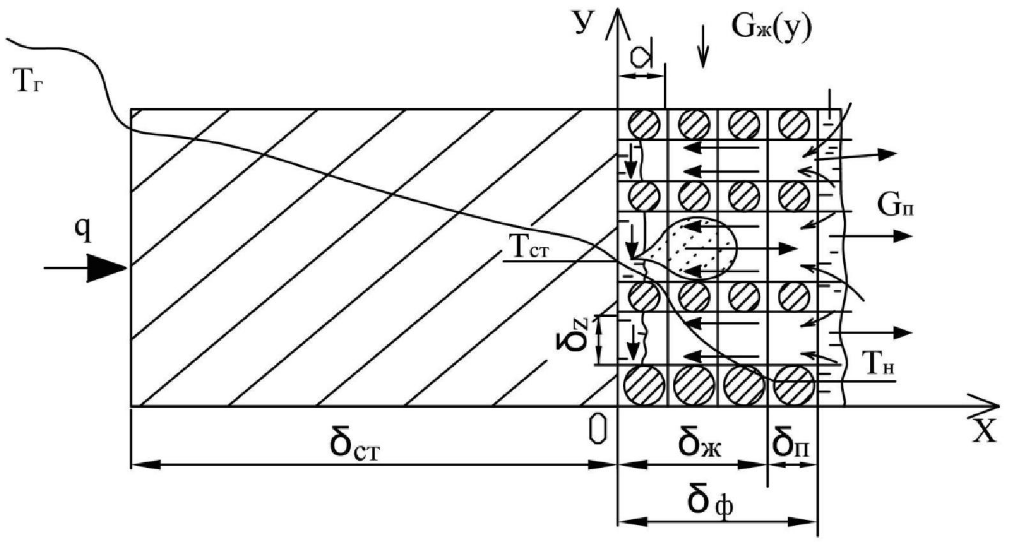

Figure 1 – Physical model of heat and mass transfer in a porous structure covering the coolable surface: Straight lines – fluid movement; wavy lines – steam movement: q – thermal flow, T_g, T_w, T_s – temperatures of gases, walls and saturation; $G_l(y)$, G_s – liquid and steam flow rates; δ_w, $\delta_{p.c.}$, δ_l, δ_s – steam-generating surface, porous coating, liquid and vapor thicknesses, b_z, d – width of porous coating cells and grain diameter

Mechanism and calculation of the critical state of the heat transfer surface. experimental data analysis. The results of the calculations are shown in figure 2-5. The maximum thickness of the particles that break off under the compression forces for granite coatings is $(0{,}25\text{-}0{,}3)\cdot 10^{-2}$ m, which is in agreement with the results obtained by high-speed filming. Sections of the compression curves, which determine the breaking-off of particles with a size $\delta>0{,}3\cdot 10^{-2}$ m for large thermal flows and small ones τ, are screened with the melting curve, and in the case of small thermal flows and significant time intervals, they are screened with the expansion curve.