Influence of structural characteristics of porous materials on heat transfer intensity

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Porous materials are widely used in industry. These are polystyrene foam materials, aerated concrete, some highly fire-resistant materials, foam glass, expanded clay. Porous materials have also occupied a niche in innovative technologies: combustion chambers, turbine walls, solar station receivers, thermal storage.

Let's take a closer look at the effect of pore location on the thermal conductivity of the material. Uses the following designations: - porosity, $\lambda1$ - heat transfer coefficient of the material (silica material with a heat transfer coefficient of 0.12 W/(m·K) was chosen as an example) $\lambda2$ is the thermal conductivity coefficient of the medium (in the example selected air with gas admixtures having a thermal conductivity of 0.019 W/(m·K)). Heat flow is directed from the bottom upwards.

Most of the existing studies of porous structures of materials for thermal protection of elements of industrial power plants take into account the total porosity as the main structural characteristic of the thermal insulation material, and sometimes take into account either the shape of the pores and their number or the type of pores. The analysis of the current literature shows that even the simultaneous consideration of the total porosity of the material, the size and type of pores is not enough to fully characterize the porous structure of the heat-insulating material. It is proposed to pay attention to the following main factors in porous systems: the nature of the structure, the number of structure components, the aggregate state of the structure components and the processes of interaction between the structure components. These complex indicators are convenient for the separation of porous systems as a whole because they allow controlling the thermophysical properties of a particular macroporous material by changing the porosity structure. But these indicators do not allow to find the functional dependence of the thermophysical properties of heat-insulating materials on the porous structure, which does not allow to optimize the thermophysical properties of porous heat-insulating material by creating predictable porous structures. Therefore, we propose the main complex indicators of the porous structure of the heat-insulating material and structures of thermal protection of elements of industrial power plants, which fully reflect the porous structure and make it possible to draw up a regression equation for the dependence of the thermal properties of porous heat-insulating materials on the proposed indicators.

1) Porosity. Porosity as a general indicator of the density of thermal insulation material and thermal protection structures.

2) Number of pores. The number of pores for a homogeneous structure in combination with porosity gives a general idea of the distribution of pores in the material. The change in the number of pores over time during the formation of the porous structure of heat-insulating materials expresses the dynamics of the pore formation process.

3) The location of the pores in space - described by the Brave translation system (Brave lattice), in which the pore is the core of the lattice with dimensions smaller than the Wigner-Seitz cell, or the statistical distribution of pores in the volume of the insulating material.

4) Pore shape - a spatial coordinate function describing the shape of the pore. It is possible to accept the description of all pores as spheres with the description of the deformation inherent in this sphere, according to the Poincaré hypothesis, or the overall dimensions of the pore, or the general coefficient of geometric characteristics of the porous structure.
5) Indicators of the gas state in the pores - the temperature gradient on which convection in the pores and the physical properties of the coolant in the pore depend. It can also be represented by the product of Grasgoff number and Prandtl number.
6) Specific surface area porosity.

Experimental study of the heat flux densities distribution in different types of triple-pane windows

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Abstract: The article examines the distribution of the heat flux densities on the external and internal surfaces of triple-pane windows, considering various gas filling, emissivity coatings and using the electrical heating. The comprehensive experimental study was conducted in a climatic chamber for air-filled window with emissivity $\varepsilon=0.84$ and argon-filled window with emissivity $\varepsilon=0.17$. In addition, the use of local and surface electric heating was investigated. The non-uniformity of heat flux densities distribution at the lower, central and upper part of each window was established, which in turn shows an error in the calculations based on stationary heat transfer conditions.

Introduction

Windows and glazed facades play a major part in the character of a building, providing natural light, solar gains, ability to view the outside and air ventilation. However, they contribute up to 60% of the total heat loss through the building envelope, due to their comparably larger overall heat transfer coefficients [1]. Hence, transparent building partitions with high thermal resistance have a significant potential to substantially increase energy savings. The thermal resistance of the double-pane window filled with air is proving to be 1.7 times lower than of the triple-pane window with the same thickness. It is due to the fact that the central pane in the triple-pane window causes reduction in the velocity of free-convective flow of the fluid in the gap between panes [2]. The fluid rises along the hot pane, changes the direction of flow in the upper part of the window and falls down along the cold pane, creating a primary circulation. Besides, multicellular secondary circulations occur in the gaps of double- and triple-pane windows over the critical values of the Rayleigh number, thus cause short cuts between hot and cold surfaces [3]. Comparing with the double-pane window, the number of multicellular circulation is higher due to the lower temperature gradient in the gaps of triple-pane window. Moreover, the central pane contributes more substantially to the decrease in the radiative heat transfer, acting as a screen [4]. The heat transfer in triple-pane windows is the