EFFICIENCY OF CYLINDRICAL POROUS BURNERS[1]

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Development of thermal energy sources based on the gas combustion with controlled temperature and capacity characteristics is an actual problem in modern science and industry. Combustion in porous media is one of the effective methods for burning gaseous fuels. Combustion here occurs with heat exchange between the flame zone with a porous body. Heat from the combustion zone is transferred along the porous frame towards the gas flow and heats the mixture of initial reactants. In contrast to the open (unrestricted) flames, porous burners are characterized by the possibility of combustion of the lean mixtures, a broad range of power adjusting, the higher firing rates and better environmental category. The porous body is heated and emits the energy from the outer surface in IR range. Due to this effect, porous burners are successfully used for heating industrial zones and creating electricity generators based on TPV modules, as well as for drying and thermal processing of materials [1-3].

The main characteristic of the radiant porous burner is the radiation efficiency, η, which is defined as the ratio of the amount of radiated energy value to the total capacity of the burner. The radiative characteristics of porous burners are largely determined by the temperature of the outer surface of porous body which, in turn depends on the rate and kinetics of burning reaction, flame localization and the characteristics of the material. The cylindrical form of the burner contributes to a uniform gas supply and uniform stabilization of the flame front inside the porous body. It allows to translate the energy of the fuel to the radiation most effective [4]. The aim of this study is to determine the porous body parameters which influence on the radiation efficiency of the cylindrical burner. Simulation is carried out within the frame of a two-temperature diffusive-thermal model [5], consisting of the thermal conductivity equations for a solid porous frame and gaseous fuel, and diffusion equation for the lacking component of the gas mixture. Quartz has been chosen as material of the porous body.

Numerical solutions have been obtained for the different porosity values, m, and average pore diameter, dp. It has been found that porosity has significant effect on the radiative efficiency of the burner. In instance, for m = 0.5 the maximal value of η is 25% and for m = 0.7 the maximal value of η is 43%. Calculations for m = 0.7 are consistent with the experimental data obtained in [5]. It should be noted that efficiency of the porous burner increases with further increase in porosity. However, the maximum of porosity is limited by the strength characteristics of porous material. If the porous body is heated unevenly then the thermal stresses occur, which are able to destroy the porous body.

The estimate of influence of the average pores diameters on the maximal radiation efficiency value has been also made. Calculation results have revealed that there is an optimal value of dp = 4 mm, at which the maximum efficiency is achieved for the given porosity value. The efficiency is less by 5-10% for the range of values $dp \in [1;4) \cup (4;6]$ (mm). It has been established that the optimal pore diameter for the considered porous material, is the same for different porosity values in the investigated range of $0.5 < m < 0.8$. Proceeding from the obtained results, it can be concluded that for a particular porous burner the maximal radiation efficiency is achieved at a certain average pore diameter and maximal possible porosity (if only remains the structural strength of the material).

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