FEATURES OF FILTRATION GAS COMBUSTION INSIDE A POROUS CYLINDRICAL PIPE WITH AXIAL GAS FLOW*

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The filtration gas combustion in a porous tube with injection of a combustible mixture through the end surface of a porous cylindrical tube is theoretically studied. This scheme of filtration gas combustion can be used to create chemical reactors for non-contact heating of various materials to high temperatures. The samples under treatment can be placed inside a porous tube, the side surface of which is covered with quartz shells transparent for infrared radiation emitted by porous carcass. The outer surface of porous reactor is heat insulated. Radiation from the surface of the porous solid phase allows heating materials under treatment to high temperatures. The simulation of the filtration gas combustion was carried out in the framework of the two-temperature thermal-diffusion model [1–3]:

$$\rho_g c_g\left(\frac{\partial T_g}{\partial t}+u_z\frac{\partial T_g}{\partial z}\right)=\lambda_g\left(\frac{1}{r}\frac{\partial T_g}{\partial r}+\frac{\partial^2 T_g}{\partial r^2}+\frac{\partial^2 T_g}{\partial z^2}\right)+Q\cdot A\cdot Y\cdot\exp\left(-\frac{E}{T_g R}\right)-\frac{2Nu}{d_p^2}(T_g-T_s)$$

$$\rho_s c_s\frac{\partial T_s}{\partial t}=\lambda_s\left(\frac{1}{r}\frac{\partial T_s}{\partial r}+\frac{\partial^2 T_s}{\partial r^2}+\frac{\partial^2 T_s}{\partial z^2}\right)+\frac{2Nu}{d_s^2}(T_g-T_s) \tag{1}$$

$$\frac{\partial Y}{\partial t}+u_z\frac{\partial Y}{\partial z}=D\left(\frac{1}{r}\frac{\partial Y}{\partial r}+\frac{\partial^2 Y}{\partial r^2}+\frac{\partial^2 Y}{\partial z^2}\right)-A\cdot Y\cdot\exp\left(-\frac{E}{T_g R}\right)$$

The problem has following boundary conditions:
at the inlet ($z=0$) and outlet ($z=h$) end of the pipe:

$$T_g(r,0)=T_0,\qquad \frac{\partial T_s(r,0)}{\partial z}=0,\qquad Y(r,0)=Y_0,\qquad \frac{\partial T_g(r,h)}{\partial z}=\frac{\partial T_s(r,h)}{\partial z}=\frac{\partial Y(r,h)}{\partial z}=0, \tag{2}$$

at the inner ($r=a$) and outer ($r=b$) surface of the pipe:

$$\lambda_s\frac{\partial T_s(a,z)}{\partial r}=\sigma_{sb}(\Theta^4-T_s^4),\qquad \frac{\partial T_g(a,z)}{\partial r}=\frac{\partial Y(a,z)}{\partial r}=0,\qquad \frac{\partial T_g(b,z)}{\partial r}=\frac{\partial T_s(b,z)}{\partial r}=\frac{\partial Y(b,z)}{\partial r}=0, \tag{3}$$

Where Θ – the parameter, which sets the level of radiation heat flux from the inner surface of the pipe.

Simulation was performed by using of the finite element method. The result of the calculations is a sequence of stationary solutions of the system (1-3). Numerical modeling allowed to evaluate the range of gas flow rates at which a stable combustion regime was observed, to find the temperature distribution in the gas and the porous body, and to evaluate the radiation fluxes inside the reactor. The influence of heat loss and the geometric characteristics of the reactor on the flame stabilization was studied.

REFERENCES

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