NUMERICAL MODELING OF FLAME DYNAMICS IN A VARIABLE CROSS-SECTION CHANNEL

A.D. ZAKHAROV, E.S. ODINTSOV, R.V. FURSENKO

Khristianovich Institute of Theoretical and Applied Mechanics SB RAS, Novosibirsk, Russia

Premixed gas combustion in inert porous media attracts the attention of researchers, since it has some typical features important for practical applications in power engineering and chemical industry. To improve the fundamental understanding of the combustion process in porous media, experimental methods and numerical modeling are often used.

Previously, we proposed a model one-layer porous burner, allowing to study flame characteristics at the pore scale [1]. Several typical patterns of flame front behavior during upstream and downstream flame propagation were experimentally identified. In certain regions of the burner, FREI-like oscillations of the flame front occurred, while in other regions, the flame propagated without oscillations. To understand the effect of the problem parameters on the dynamical behavior of the flame in porous media, in this paper we propose a simplified model describing flame propagation in a heated variable cross-section channel. This model describes main features of the porous media combustion and allow us qualitative estimate the influence of parameters on the appearance of a particular pattern.

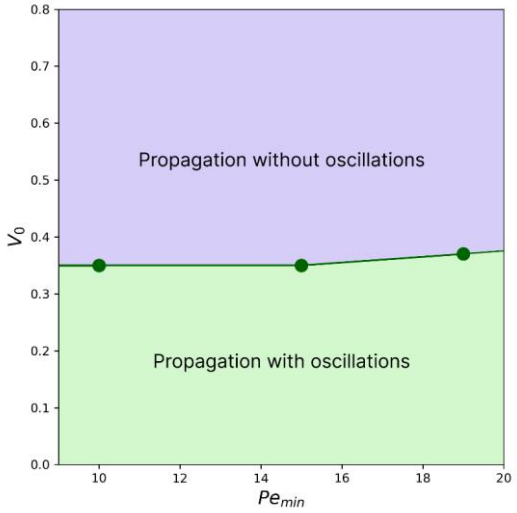

Fig.1. Parameter regions determining flame propagation regime.

Several numerical modeling scenarios were conducted. Two flame upstream propagation regimes, similar to those observed in experiments, were identified. The figure illustrates the dependence of the dimensionless flow velocity V_0, at which a transition between flame propagation regimes occurs, on the Peclet number in the narrowest part of the channel. Here, $V_0 = U/U_b$, where U is the dimensional flow velocity, and U_b is the adiabatic flame speed. Parameter regions above the line correspond to flame propagation without oscillations, whereas regions below the line correspond to the regime with FREI-like oscillations. It is important to note that the velocity value at which the flame propagation regime changes is weakly dependent on the Peclet number.

The effect of other model parameters was also studied. It was found that the flow velocity at which a transition between flame propagation regimes occurs is weakly dependent on parameters such as thermal conductivity of the solid phase, heat exchange intensity between phases, and channel geometric parameters. When varying these parameters over a wide range, the flow velocity at which the flame propagation regime changes varied within 10%. It can be concluded that for porous media with different characteristics, flame propagation regimes are primarily determined by the flow velocity.

REFERENCES

[1] Roman V. Fursenko, Igor A. Yakovlev, Egor S. Odintsov, Sergey D. Zambalov, Sergey S. Minaev, “Pore-scale flame dynamics in a one-layer porous burner,” Combustion and Flame, Volume 235, 2022, doi: 10.1016/j.combustflame.2021.111711