HYDRODYNAMIC PHENOMENA DURING PREMIXED LAMINAR FLAMES PROPAGATION IN CHANNELS

A. G. Istratov[1], N. I. Kidin[2], A. F. Fedorov[3]

[1] Semenov Institute of Chemical Physics, RAS, Moscow, Russia
[2] Institute for Problem in Mechanics, RAS, Moscow, Russia
[3] Institute of Structural Macrokinetics and Materials Science, RAS, Chernogolovka, Russia,
e-mail: ipm-fedorov@yandex.ru

The paper deals with numerical investigations of premixed laminar flame propagation in the flat half-open channel with essentially subsonic gas flows. The CFD simulations were based on the Naviers-Stokes equations. The chemical reaction rate or heat release was assumed to be under the Arrhenius law. The viscosity, thermal conductivity and diffusion factors were constant. The gravity was not taken into account.

Numerical experiments showed the possibility of two different regimes of flame propagation (cellular flame and “tulip”) when ignition occurred from the open end. Such regimes arisen due to the slipping (cells) or no-slipping (“tulip”) of gas flows at the channel walls. The number of cells linearly increased with the increase of the channel width, tulip configuration did not vary with a similar change. The analysis of thermal and hydrodynamical structure of such flames has shown the qualitative similarity of "tulip" and cells structures near the flame cracks ("bosoms"). Besides, it was shown that such configurations could be led one to another by affine transformation along the axes of coordinates. The factors ratio of transformation did not depend on the Reynolds number and was determined for different Lewis numbers depending on thermal expansion.

Interaction of a flame with a vortex arising behind thin obstacle in the channel when ignition was carried out at the closed end of the channel was investigated. The vortex pushing out to the open end by expanding products and formation of cavities of a not burned gas in products by twisting the flame front was revealed. The last case arisen due to the "stretch"-effect. The Karlovitz parameter along the front had minima on the sites of the front where the fusion of a gas mixture layer occurred.

Another problem under investigation was to determine the limits of flame propagation through a gap formed by an obstacle and a channel wall. Adiabatic conditions on the channel walls were changed to a condition of the constant temperature (for a flow field the condition of no-slipping was assumed). The limits of flame propagation could be as noticeably larger and essentially less than the classical ones of flame front propagation. It was also shown that for the channels with the width larger than the classical extinguishing width the probability of oscillatory flame propagation of non acoustic nature depended on the initial conditions.