Vol. 13, No. 4, 2004

Stability of Thermal Front with Heat Conductivity Dependent on Temperature

Petr M. Krishenik[1] and Konstantin G. Shkadinskii[2]

[1]*Institute of Structural Macrokinetics and Material Science Problems, Russian Academy of Sciences, Chernogolovka, Moscow Region, 142432*
petr@ism.ac.ru
[2]*Institute of Problem of Chemical Physics, Russian Academy of Sciences Chernogolovka, Moscow Region, 142432*
shkad@icp.ac.ru

ABSTRACT

The structure of combustion wave and nonstationary wave propagation with a nonlinear heat transfer $\lambda(T)=\lambda_c(T/T_c)^n$ was studied using a one-dimensional numerical model. At the assumption on strong activation of the chemical reaction and high-energy exothermic conversion, approximate analytical solutions that characterize the flame front structure were obtained. Despite the nonlinearity of the $\lambda(T)$ dependence, a classical expression retaining the exponential character of the temperature dependence was derived for the front propagation velocity u. In the first approximation, it was found that the area of reaction zone of an efficient chemical interaction was weakly dependent on n, and it corresponded to the commonly used term in the expression of combustion theory. A significant decrease in the heating zone width led to a reduction in enthalpy excess ΔH in the combustion front. The enthalpy excess $\Delta H(n)$ was examined to evaluate the stability of the wave structure. At n the enthalpy excess in the heating zone was $\Delta H(n) = \Delta H(0)/(n+1)$.

To investigate the stability of the solutions, the procedure of the small-perturbation method was used. The frequency of oscillation at the boundary of oscillation stability and the critical value of Zeldovich number Ze characterizing the boundary of the combustion front stability was determined.

The nonstationary problem of the flame front propagation was numerically analyzed for various values of parameter n. The width of the reaction zone was weakly affected by variations of n. The heating zone width was reduced with the increase in the n value. The dynamics of transition from the bi-frequency periodic oscillatory regime at $n=0$ to a uni-frequency oscillatory regime at $n=1$ and a stable stationary one at $n=3$ was studied.