TURBULENT COMBUSTION ANALYSIS USING THE RENORMALIZATION-GROUP METHOD

Sorokina Tatyana Viktorovna
Institute of engineering thermophysics Ukraine National Academy of Sciences
тел. (044) 453-29-93

In the present investigation an attempt was made to create a model using of renormalization technique. Renormalized diffusion coefficient (*D*) and constant of reaction rate (*K*) have been obtained after procedure of renormalization.

Initial equation of diffusion with nonlinear outflow combust and oxidant at reaction of combustion has the following form:

$$\frac{\partial y}{\partial t}+\lambda\frac{\partial}{\partial x_\alpha}\left(u_\alpha y\right)=D_0\nabla^2 y-\lambda K_T y y_{ox}\left(1-Ze\cdot\theta\right),$$
$$\frac{\partial y_{ox}}{\partial t}+\lambda\frac{\partial}{\partial x_\alpha}\left(u_\alpha y_{ox}\right)=D_0\nabla^2 y_{ox}-\lambda K_T y_{ox} y\left(1-Ze\cdot\theta\right). \qquad (1)$$

where t — time, u_α — velocity component is according to axis x_α, λ — perturbation parameter, y and y_{ox} — concentration of combustible and oxygen compound according to, D_0 — diffusion coefficient, K_T — temperature reaction rate constant, , $\mathrm{Ze}=\frac{E\left(T_b-T_0\right)}{RT_b^2}$ – number of Zeldovich, $\theta=\frac{T-T_0}{T_b-T_0}$ – nondimensional temperature, T_b – theoretical flame temperature according to thermodynamically-equilibrium combustion products.

The renormalization operation is carried out in the space of wavenumbers and frequency. To convert equation (1) into this space, it is necessary to use the complex Fourier transform. Then we apply the procedure of the renormalization analysis.

An effective renormalization coefficient of diffusion is obtained by analytical method. This coefficient characterizes the transfer (mixing) of fuel and oxidizer in space, due to the turbulent motion of the medium during chaotic fluctuations of speed, temperature, pressure and density. The kinematic viscosity of gas is decrease and turbulence diffusivity is increase with a rise a temperature of process of turbulent combustion.

$$D=D_0+\frac{d-1}{d}\frac{S_d}{\left(2\pi\right)^d}\frac{\lambda^2 B}{\nu_0^2}\frac{\nu_0}{\nu_0+D_0}\frac{\exp\left(\varepsilon*\tau\right)-1}{\kappa_c^{\varepsilon*}\varepsilon*},$$

where $S_d=\frac{2\pi^{d/2}}{\Gamma\left(d/2\right)}$, ε - parameter, equal four, d – space dimension.

Various expressions of the reaction rate constant are derived depending on the transformation of the exponential factor and the choice of the terms of equation (1), which have been renormalized. The reaction rate constant depends on the temperature and the nature of the reactants. With increasing temperature, the Prandtl number decreases and the reaction rate increases.

As a result of the study, a renormalization diffusion coefficient ΔD and a renormalization reaction rate constant ΔK were obtained by using the renormalization analysis. Mathematical model for turbulent combustion is derived analytically.