EFFECTS OF LEWIS NUMBERS ON GASEOUS COMBUSTION IN INERT POROUS MEDIA

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Under combustion of a homogeneous mixture in an inert porous medium there are possible several steady-state regimes: low velocity regime (LVR, characteristic velocity of the combustion wave $S \approx 10^{-4}$ m/s), high velocity regime (HVR, $S=10^{-1}$-10^{1} m/s), sound velocity regime (SVR, $S=(1\text{-}7)10^{2}$ m/s), low velocity detonation (LWD, $S \approx 800$-1000 m/s), normal detonation with heat and momentum losses (ND, $S>1500$ m/s) [1]. Effects of Lewis numbers on gaseous combustion in inert porous media manifest themselves in different regimes both at the flammability limits and in the flame propagation regions [2]. It is of common regard that deflagration and detonation waves cannot pass through a porous body with channels less than critical diameter, d_c. The critical condition of chemical reaction extinction in a combustion wave is the constancy of the Peclet number, $Pe=S_u d_c/\kappa=const$, based on laminar burning velocity, S_u, characteristic channel diameter of a porous body, d_c, and thermal diffusivity of combustible gas, κ. It is found that Peclet numbers at the flammability limits calculated on the initial parameters of the combustible mixtures are not constant as usually considered. In hydrogen- and methane-air mixtures they increase and in propane-air mixtures they decrease with enriching the mixture with fuel [3].

These tendencies are regular and they are of universal character. A big set of the authors' and literature experimental data can be generalized by the function of $Pe_N = Le_{ef}$, where Le_{ef} is the effective Lewis number and $Pe_N=Pe/Pe_{st}$, Pe_{st} – critical value of the Peclet number for the stoichiometric mixture. As applied to this problem, the hypothesis of selective diffusional demixing is also considered. It is also shown that Peclet numbers in PM calculated with taking into account of the effect of selective diffusional demixing are constant at the flammability limits. For the generalization of experimental dependences of flame propagation velocities on initial parameters in the HVR and SVR, generally the dependences of Re, $Re=(S-S_u)d/\nu$, on $Pe=S_u d/\kappa$ are used. Here S is flame propagation velocity, ν - the kinematics viscosity. Lewis numbers effects inside the flammability limits manifest themselves via segregation dependences of $Re(Pe)$ for different mixture compositions. At that, for methane- and hydrogen-air mixtures the leaner the mixture the lower Pe at the flammability limit and the more Re at a given Pe. For propane-air mixtures quite the contrary the richer the mixture the lower Pe at the flammability limit and the more Re at a given Pe.

The normalization of Pe to Le_{eff} allows one to generalize all data by a single curve. For taking into account Lewis number effects and introducing corresponding corrections into the equations for critical conditions and flame velocity in porous media one needs to consider two Lewis numbers based on diffusion coefficients of fuel and oxidizer. These numbers may be presented separately as Le_f and Le_{ox} or in general form as effective Le_{eff}. It is reasonable to correct calculation schemes for porous flame-arresters with taking into account of the Lewis number effects.

References

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