Filtration gas combustion in high porosity fibrous porous media

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Abstract

Combustion of lean methane-air mixtures under filtration in inert, low-density, high-porosity and low-conductivity fibrous porous media was studied experimentally and analytically. Between upstream and downstream propagating regimes, a specific standing wave regime was observed, whereas only one standing wave point existed in other ordinary porous media. In addition, one specific instability phenomenon that combustion wave split into two or more parts during wave propagating downstream was also observed in smaller diameter tubes. A general analysis of the combustion wave propagation in fibrous porous media within frame of 1D two-temperature model taking radiative heat transfer into account was presented. The calculated combustion wave propagation velocities were compared with experimental results and it showed qualitative agreement in the upstream propagating regime. Further investigation indicated that the combustion characteristics in fibrous porous media were described very well by the combination of classical combustion theories in tubes at $Pe < Pe_{cr}$ for upstream propagating regime and at $Pe > Pe_{cr}$ for both standing and downstream propagating regimes. In principle, the standing wave regime was regarded as another illustration of hysteresis phenomena which were first reported in narrow tube.

Key words: Filtration gas combustion; fibrous porous media; standing wave; flame instability