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OSCILLATORY FLAME INSTABILITY IN POROUS MEDIA*

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Porous media combustion (PMC) is of great interest for last decade due to specific advantages such as enhanced flammability range, low pollutant emission and improved flame stability in contrast to free-flame burners [1]. Global course to emission reduction of greenhouse gases and fuel saving prompts to use lean mixtures in burner devices down to lean limit. Intense heat recuperation in PMC allows extremely decrease fuel concentration in combustible mixture till $\varphi \approx 0.15$ [2]. However, some types of flame instabilities can develop under such conditions.

In this study a pore-scale numerical simulation of the flame behavior in two-dimensional randomly-backed bed of circle particles (7 mm in diameter) has been performed for methane-air mixture. The computational domain consisted of fluid and solid regions. Mathematical problem statement, based on the finite volume method, described the fluid flow in the interstitial space with chemical reaction, thermal conductivity of the solid particles as well as conjugate heat transfer and radiation. Full problem statement can be found in [3].

The combustion wave propagates upstream with velocity of ~0.01 mm/s. During that fragments of the flame front oscillates with frequency of ~50 Hz. Figure 1a shows the temperature contour at the case when the macroscopic wave reaches center section of the domain.

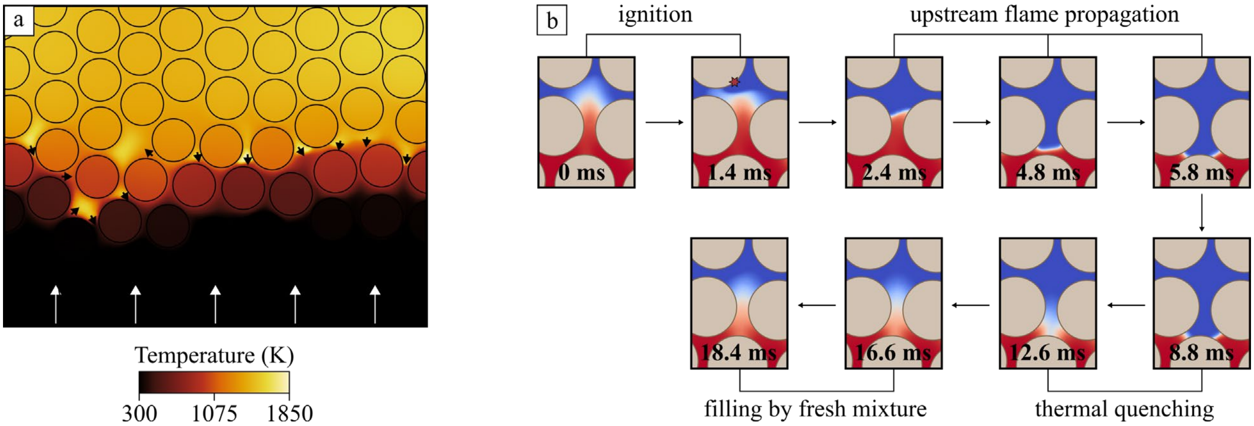

Fig.1. Temperature distribution (a) and flame front behavior in pore channel (b).

At pore scale the flame front propagation is a repeatable process of mixture ignition, upstream flame propagation, thermal quenching and filling the channel with fresh mixture. These stages are similar with the unstable flames with repetitive extinction and ignition (FREI), observed in microchannels with external heating [4]. Considering the significant tortuosity of the pore channels with temperature gradient as a result of heat recuperation mechanism, the mechanisms are identical. In contrast to straight channels that flame front fragments in adjacent connected channels can influence each other hydrodynamically (pulsations of the pressure and flow rate) and thermally. In microchannels some transitional regimes without full flame extinction have been observed. In this study small oscillations with frequency from 150–300 Hz have been predicted numerically for the case with small particles diameter of 1.5–2 mm.

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