COMBUSTION OF A PRE-MIXED METHANE-AIR MIXTURE IN A CO-AXIAL COUNTER FLOW REACTOR

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Environmental issues come to the fore for today's society stimulating development of eco-friendly technologies. Thus, fundamental studies of combustion regimes and extinction limits in perspective systems for low-calorific fuels burning are of great importance.

In this work, the combustion of premixed methane-air mixtures in co-axial counter flow reactor is studied. Reactor consists of inner and outer tubes nested into each other as shown in Fig.1. A fuel-lean methane-air mixture with equivalence ratio φ_{out} varied from 0.4 to 0.8 is fed into the outer tube. In the inner tube either pure methane ($\varphi_{in}=\infty$) or a rich methane-air mixture with φ_{in}=1.5, 2.5 and 3.5 is supplied. Numerical simulations were performed by means of OpenFOAM software. In the course of numerical simulations mixture flow rates and equivalence ratios in the inner and outer tubes were varied.

It was found that depends on problem parameters various combustion regimes characterized by the number, shape and relative position of the flame fronts can be realized. In the case of pure methane flow in the inner tube the two-layered flame structure is observed. In this case shown in Fig.1 the lean premixed cup-like flame and small diffusion flame near the outlet of the inner tube are stabilized. Results of numerical simulations allowed us to conclude that high-temperature zone appearing due to the diffusion combustion play stabilizing role for cup-like flame and causes expansion of extinction limits. In the case of rich methane-air mixture supply in the inner tube the three-layered flame structure consisting of lean premixed flame, diffusion flame and rich premixed flame is observed. Effect of mixtures equivalence ratio and flow rates on flame structure and shape are discussed. Results of numerical simulations are compared with experimental data. Example of such comparison is shown in Fig.1. It was shown that applied simplified model allow to reproduce main features of combustion in the examined system and provides a clear physical interpretation of experimental findings.

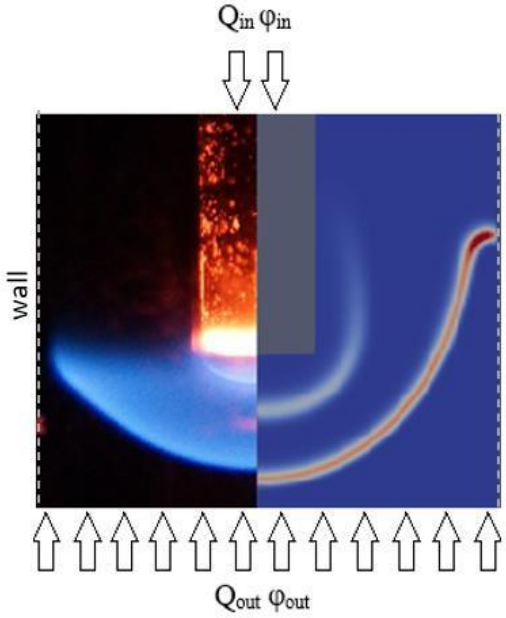

Figure 1. Experimental photo and numerical result on heat release demonstrating cup-like flame and diffusion flame typical for twolayered flame structure (Q_{in}=0.005 l/min, $\varphi_{in}=\infty$, Q_{out}=5.9 l/min, φ_{out}=0.7)

Keywords

Fuel-lean mixtures combustion, premixed flames, diffusion flame, counterflow reactor, CFD.

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