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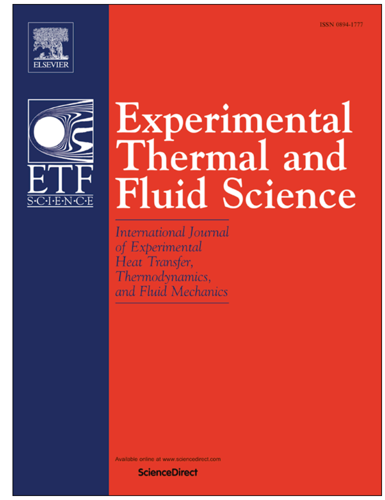

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Lu-Qing Wang, Hong-Hao Ma, Zhao-Wu Shen

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Effect of orifice plates on detonation propagation in stoichiometric hydrogen-oxygen mixture

Lu-Qing Wang[a], Hong-Hao Ma[a,b*], Zhao-Wu Shen[a]

[a]*CAS Key Laboratory of Mechanical Behavior and Design of Materials (LMBD), University of Science and Technology of China, Hefei 230026, Anhui, P.R. China*

[b]*State Key Laboratory of Fire Science, University of Science and Technology of China, Hefei 230026, Anhui, P.R. China*

Abstract:

In this study, experiments were carried out in a circular tube (5300mm long, 48mm inner-diameter) filled with orifice plates to investigate the detonation behaviors of stoichiometric hydrogen-oxygen mixture. Two kinds of orifice plates, i.e., round orifice plates and square orifice plates were used to generate obstacle configurations with various spacings. The blockage ratios of these orifice plates are 0.56. Evenly spaced photodiodes were mounted on the tube wall to record the detonation velocity. Long soot foils were adopted to study the evolution of the cellular structure. The detonation propagation limits (also the quasi-detonation limits) were found to be in agreement with $d_{eff}/\lambda >1$, where d_{eff} and λ are the effective diameter of the orifice and the detonation cell size. The measured velocity as well as the propagation limits are independent of the opening geometry as long as the effective diameters are identical. Soot foils obtained with various sensitivity (or initial pressure) exhibit that the re-initiation of detonation occurs via a variety of modes. Well within the limits, the detonation could recover via the generation of hot spots. In some cases, a detonation can propagate without the formation of hot spots. Near the limits, only a few transverse wave traces or streaks can be observed, indicating that the propagation mechanisms are changed.

Key words: Hydrogen-oxygen; Detonation propagation limits; Orifice plates; Cellular structure

1 Introduction

Hydrogen has been recognized as a promising energy carrier due to its unique advantages, such as high calorific value and reduced NO_x/SO_x emission. Currently, hydrogen is used widely in industrial process, such as Haber process [1], transportation and chemical power plants [2,3]. However, safety problems still persist constantly on account of its wide flammability limit, high explosion pressure and rate of pressure rise [4], and extremely low ignition energy. In spite of the extraordinary buoyancy of hydrogen, accidental leakage in a confined space can be tremendous dangerous [5]. An ignition of the leakage will cause a deflagration or even the worst, a detonation. Therefore, the hydrogen detonation characteristics and basic parameters are needed for safety assessment, aiming at protecting the infrastructures.

Detonation propagation limits refer to the critical condition beyond which a stable detonation cannot self-sustain [6]. Up to now, a number of investigations on this topic have been launched in tubes with various wall properties. In smooth tubes, the detonation behaviors are considerable complex near the limits and no universal criterion for limits prediction is available. At the limits, the detonation mode can be single-headed spin [3,7-15], galloping detonation [16,17], stuttering

* Corresponding author: H. H. Ma (hhma@ustc.edu.cn)