Available online at www.sciencedirect.com

ScienceDirect

Natural Gas Industry B xx (2017) 1–6

www.elsevier.com/locate/ngib

Research Article

Combustion characteristics of porous media burners under various back pressures: An experimental study

Zhang Xuemei*, Li Heying, Zheng Lu, Chen Zhiguang, Qin Chaokui

School of Mechanical and Energy Engineering, Tongji University, Shanghai 201804, China

Received 28 October 2016; accepted 25 February 2017

Abstract

The porous media combustion technology is an effective solution to stable combustion and clean utilization of low heating value gas. For observing the combustion characteristics of porous media burners under various back pressures, investigating flame stability and figuring out the distribution laws of combustion gas flow and resistance loss, so as to achieve an optimized design and efficient operation of the devices, a bench of foamed ceramics porous media combustion devices was thus set up to test the cold-state resistance and hot-state combustion characteristic of burners in working conditions without back pressures and with two different back pressures. The following results are achieved from this experimental study. (1) The strong thermal reflux of porous media can preheat the premixed air effectively, so the flame can be kept stable easily, the combustion equivalent ratio of porous media burners is lower than that of traditional burners, and its pollutant content of flue gas is much lower than the national standard value. (2) The friction coefficient of foamed ceramics decreases with the increase of air flow rate, and its decreasing rate slows down gradually. (3) When the flow rate of air is low, viscosity is the dominant flow resistance, and the friction coefficient is in an inverse relation with the flow rate. (4) As the flow rate of air increases, inertia is the dominant flow resistance, and the friction coefficient is mainly influenced by the roughness and cracks of foamed ceramics. (5) After the introduction of secondary air, the minimum equivalent ratio of porous media burners gets much lower and its range of equivalent ratio is much larger than that of traditional burners.
© 2017 Sichuan Petroleum Administration. Production and hosting by Elsevier B.V. This is an open access article under the CC BY-NC-ND license (http://creativecommons.org/licenses/by-nc-nd/4.0/).

Keywords: Low heating value gas; Porous media; Combustion; Different back pressure; Cold state; Hot state; Equivalent ratio; Pollutant emission; Friction coefficient; Solid Oxide Fuel Cell (SOFC); Experimental study

China is now in a stage of rapid economic development, however, its economy is more and more restricted by energy and environment. In terms of energy utilization, on the one hand, there are problems like low efficiency and severe pollution and waste, and on the other hand, a large amount of low-grade energy hasn't been developed and utilized yet. To establish an economic model of sustainable development, improve energy structure and increase energy utilization rate, we must make full use of low heating value (LHV) gas in industrial production and energy production. Generally, gases with a heating value below 6.28 MJ/m^3 are LHV gas fuels, such as blast furnace gas, SOFC tail gas, LHV gas generated from chemical process and acetylene and methane generated from biomass pyrolysis [1–3]. Combustible components in LHV gas are thin, which are difficult to be utilized through conventional combustion technology and direct emission is a waste and pollutes atmosphere. Therefore, it is urgent to develop a new type of combustion technology suitable for LHV gas [4]. Porous media combustion technology is an effective solution to stable combustion and clean utilization of LHV gas [5–7].

Porous media combustion (PMC) is a combustion process of combustible gas and oxidizing agent flowing though porous media pores, which is also called filtration combustion (FC). Thermal reflux in porous media is the result of combined action of conduction, convection and radiation [8–10]. The

* Corresponding author.
E-mail address: zhangxuemei@tongji.edu.cn (Zhang XM).
Peer review under responsibility of Sichuan Petroleum Administration.

http://dx.doi.org/10.1016/j.ngib.2017.08.009
2352-8540/© 2017 Sichuan Petroleum Administration. Production and hosting by Elsevier B.V. This is an open access article under the CC BY-NC-ND license (http://creativecommons.org/licenses/by-nc-nd/4.0/).

Please cite this article in press as: Zhang XM, et al., Combustion characteristics of porous media burners under various back pressures: An experimental study, Natural Gas Industry B (2017), http://dx.doi.org/10.1016/j.ngib.2017.08.009

premixed air reacts and releases heat and heats the solid framework in the reaction zone through gas–solid convection, then heats the upstream solid framework through solid heat conduction and radiation effect and then heats the premixed air through gas–solid convection and heat exchange. Therefore, PMC technology has the advantages such as high power, adjustable range, high power density, very low pollutant emission, compact structure, high fuel adaptability and wide adjustable range of equivalent ratio [11–19]. The authors conducted experimental study on the combustion characteristics of porous media burners under various back pressures and in cold state and hot state, and thus observed the combustion condition of premixed air inside or on the surface of a porous media burner, investigated the flame stability range and figured out the distribution laws of combustion gas flow and resistance loss, so as to achieve an optimized design and efficient operation of the device.

1. Experiment

SOFC tail gas has relatively high temperature and pressure, and due to the low content of combustion components, it belongs to LHV gas. A porous media burner bench was set up specific to the characteristics of SOFC tail gas to conduct systematic investigation on the characteristics of flow resistance and combustion. The bench includes 4 parts: an air supply system, a combustion system, a measuring system and a control system. The combustion system includes a premixing section, a combustion section, a flame observation section, a secondary air section and a flue gas section.

The structure of the combustion system is shown in Fig. 1. At the bottom of the premixer are the inlets of fuel gas and air, which are connected by a venturi tube. Fuel gas is injected by air. A flow equalizing plate is set at the top of the burner to fully mix the air flow. The inner diameter of the burner is 108 mm and the combustion section is 150 mm long, which is filled with porous media material – silicon carbide foamed ceramics. The flame observation section is 50 mm long and the wall surface is inlaid with a piece of silica glass of 20 mm × 50 mm, through which the combustion condition can be observed during the experiment. The secondary air section is 150 mm long and is composed of inner and outer cylinders, in which the outer cylinder is opened with a secondary air inlet on one side and the inner cylinder is opened with a small hole of certain size in the radial direction, so that the secondary air can enter the inner cylinder and be mixed with post-combustion flue gas. The flue gas section can collect the flue gas by flue gas analysis device and a tube of certain length is installed at the downstream of the flue gas section to simulate different back pressures of the burner.

The temperature measuring system includes thermocouple, temperature sampling module and data-receiving computer. Totally 9 temperature measuring points and 4 pressure gauging holes are set at the combustion section. In the experiment, the composition analysis on the post-combustion flue gas was conducted by using the Quintox KM9106 Flue Gas Analyzer; auto-ignition and flame-out protection was controlled by a controller during the combustion process; the mixing ratio of fuel gas and air was adjusted by the Gasventil Siemens VGU 86 fuel gas servo magnetic valve.

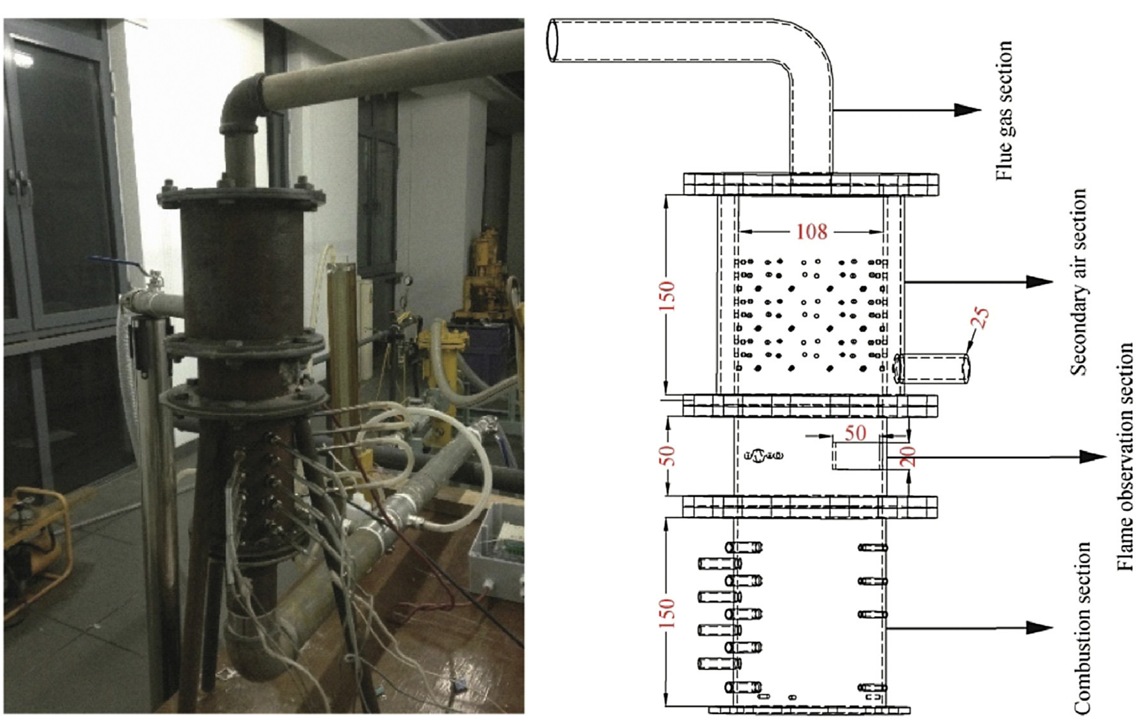

Fig. 1. The structure of the combustion system.

Download English Version:

https://daneshyari.com/en/article/8109700

Download Persian Version:

https://daneshyari.com/article/8109700

Daneshyari.com