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Combustion Mechanism of Gas Porous Burner Installed an In-Line Tube-Bank Heat Exchanger

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Abstract

The in-line tube banks heat exchanger installed on a gas porous burner using air as the working fluid and LPG as fuel is designed and experimented. Effectiveness of the heat exchanger (ε) and temperature profile of porous burner (T) are investigated. Therefore, the test rig is divided into 4 sections. The first section is premixed-gas supplying section (Air and LPG). Then, premixed-gas is preheated in the second section where this region is porous burner (PB). The ignition zone is the third section. The final section is the in-line tube-banks heat exchanger (HE). Alumina-Cordierite ball (Al-Co) having average diameter (d) of 19 mm and porosity (ϕ) of 0.395 is adopted as porous media. From heat exchanger design, stainless tube with outer diameter of 19 mm and thickness of 1 mm is developed as a 24 tube of an in-line tube-banks heat exchanger and is attached below the PB and the ignition zone. From experiment, it is found that T is increased as increasing the equivalent ratio (Φ) and the volumetric premixed-gas velocity (V_{mix}). However, the trend of T is slightly decreased as increasing the water flow rate fed into heat exchanger (Q_{AH}). In the result of ε, it is found that ε is increased as increasing Φ and V_{mix}. On the other hand, the trend of ε is decreased with Q_{AH} increasing. Thus, the maximum of ε is obtained at $\Phi = 0.75$, $V_{mix} = 30$ m^3/hr and $Q_{AH} = 42$ m^3/hr which there is 58.7%.

Keywords: *In-line tube-banks heat exchanger; Gas porous burner; Effectiveness; LPG*

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1. Introduction

The inert porous burners used gas as fuel are widely used for many purposes including spacing heating, paper dying, paper finishing, baking and textile drying [1-3]. The function of the gas porous burner is to convert the chemical energy of the combustion of the fuel into enthalpy of the product and eventually into the directed radiation. Usually, there are two advantages in this type of a burner, i.e., higher thermal radiant output and minimal pollutant emission, which are the major reasons why a number of researchers and engineers have been paid attention to theoretical and experimental studies of porous burners and improvements of the burner performances [4-6].

Usually the gas porous burner may be classified into two categories on whether the flame can be submerged in a porous medium or be anchored (spreading flame) at the surface [2]. For the submerged flame, many applications are studied in last three decade [7-10] and, commonly, a high porosity (ϕ) of 0.5 to 0.99 is employed. However, there are a lot of problems for practical work such as a difficult maintenance with the device embedded in the porous matrix, a little data of porous properties for the design of thermal equipment, the complex control of flame stability and so on. On the other hand, the problem of the submerged flame, where the porosity (ϕ) has below 0.5, is not occurred in the anchored or spreading flame because the thermal device is not installed in the porous matrix and the stable flame is easily treated [11-15].

From the advantage of the spreading flame type of the gas porous burner, the in-line tube banks heat exchanger using air as the working fluid is installed by contacting the flame on a lower porosity of the porous burner. Liquefied petroleum gas (LPG) is used as fuel. To propose the performance of the present application and the combustion mechanism, the temperature profile of porous burner (T) and an effectiveness of the heat exchanger (ε) are discussed.

Nomenclature

d	Average diameter of Alumina-Cordierite ball
HE	Heat exchanger
LPG	Liquefied Petroleum Gas
PB	Porous burner
Q_{AH}	Air flow rate fed into heat exchanger
T	Temperature profile of porous burner
V_{mix}	Volumetric premixed-gas velocity
X	Burner lenght
ε	Effectiveness of the heat exchanger
ϕ	Porosity
Φ	Equivalent ratio

2. Experimental Apparatus

Figure 1 shows the schematic diagram of a gas porous burner installed the in-line tube-bank heat exchanger. The test rig is divided into 5 sections, i.e., the injection chamber of a premixed-gas (Air and LPG), the porous burner (PB), the ignition zone, an in-line tube-banks heat exchanger (HE), and the measurement of exhaust gas section. From these sections, the experimental procedure can be described thoroughly as following:

Air and LPG are fed pass the injection chamber to a porous burner (PB). Alumina-Cordierite ball (Al-Co) having average diameter (d) of 19 mm and porosity (ϕ) of 0.395 is adopted as porous matrix. After the mixed-gas is flowed pass the PB, the gas is ignited in the ignition zone. The combustion is achieved under the PB and a spreading flame of the burner is also appeared. Thus, an in-line tube-banks heat exchanger is installed below the ignition zone to directly absorb the energy from the flame. The 304-stainless tube with outer diameter of 19 mm and thickness of 1 mm is developed as a 24 tube of an in-line tube-banks heat exchanger as depicted in Fig. 2. The working fluid of the