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Comparison of Combustion Behavior between Solid Porous Burners Installed the Porous Emitter and Non-Porous Emitter

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Abstract

The combustion behavior, i.e., temperature profile (T), exhaust gas (CO and NOx) and combustion efficiency (η_C), of solid porous burner installed porous emitter and non-porous emitter were compared. The stainless wire-net having PPI (Pores per inch) of 12 and thickness (H_{PE}) of 3 layer was selected as porous emitter. A rice husk with humidity percentage in the range of 12 - 14% was solid fuel. A cylindrical porous burner was made of ASUS 304 and there was 100 mm-outer with 5 mm- thick. An alignment of porous burner was in the horizontal direction. The fuel was supplied and was burned on the center of the burner. The grate was constructed below the fuel to control the flow of rice husk. The above of combustion zone along the porous burner was able to install the porous media defined here as porous emitter. Three mass fuel rates (Q_F) consisting of 0.080, 0.096 and 0.116 kg/min were examined. Four volume flow rates of air (Q_A: 10, 15, 20 and 25 m^3/hr) were conducted. From the study, the trend of T in both cases, namely the burner with installation of porous emitter and the burner with non-porous emitter, was raised as increasing Q_F but the maximum of T become at Q_A = 15 m^3/hr. The level of CO was decreased as increasing Q_F and was minimum at Q_A = 15 m^3/hr. The level of NO_x was relative low as in the rage not over 50 ppm owing to the combustion temperature was not reached to 1300 K (Thermal NOx). For comparison, the T of installation of porous case was higher than the non-porous case and, also, the level of CO of porous case become lower. Thus, the η_C of porous case reached to 95-97% was greater than non-porous case.

Keywords:Combustion behavior; Porous burner; Rice husk;, Porous emitter

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1. Introduction

During a few decades, many experiment and analysis on the combustion behavior of an inert gas porous media have been investigated [1-4] owing to their several advantages over conventional burners. The advantages are a higher thermal efficiency, a higher power density, a better flame stability and low emission (CO and NOx) [5, 6]. For the liquid porous burner, there are number of experimental and numerical studies [7-11]. In these studies, the fuel (oil) was fed in from of oil spray or drops in air at the inlet point (upstream) and the evaporation of oil was achieved with radiative heat at the outlet point (downstream). After oil vapor flow pass the downstream and mix with fresh air, the combustion of oil vapor – air mixture is occurred. Moreover, the experimental and theoretical studies of solid fuel combustion using the technique of porous media has very little. Kayal and Chakravarty [12] investigated numerically the thermal behavior of a highly porous ceramic matrix. The submicron carbon (carbon black) was used fuel and the combustion was operated by the carbon black particles suspended in air. Recently, Ponsen and Prasartkaew [13] proposed the pulsation gas flow passing the porous media to burn the solid feedstock. The biomass and municipal solid waste (MSW) were used as fuel. They reported that the maximum efficiency yielded 87% at temperature of 1000ºC.

From above two works [12, 13], this is confirmed that very little studies involving the solid combustion in/on porous media has been report so far. The present work investigates experimentally the combustion behavior of solid porous burner. The temperature profile (T), exhaust gas (CO and NOx) and combustion efficiency (η_C) are the combustion behavior to discuss in this work. A rice husk with humidity percentage in the range of 12 - 14% is used as solid fuel because Thailand is regard as an agricultural country and become a common feature to see one type of product at the local markets for a relatively short period, and naturally sold at rock-bottom prices. This leads to miserable rewards for farmers. As against this problem, the rice husk is selected as solid fuel. Moreover, to more understand the advantage of porous media, two solid porous burners: installation of porous emitter and non-porous emitter are compared.

2. Experimental Apparatus

Figure 1 shows the schematic diagram of a solid porous burner installed the porous emitter (PE). The test rig is aligned in the horizontal direction and con be divided into 3 sections; the injection zone, the solid fuel feeder and combustion chamber. From these sections, the experimental procedure can be described thoroughly as following:

The solid fuel in which is the rice husk at humidity percentage in the range of 12 - 14% is supplied from the solid fuel port and, then, is flowed along a screw conveyer into combustion chamber. A cylindrical porous burner made of ASUS 304 with 100 mm-outer and 5 mm- thick is constructed as combustion chamber. The grate is constructed below the chamber to control the flow of rice husk fed on the center of the burner. The fuel is ignited by pilot flame and the combustion is occurred. For the present study, there are two steps to investigate the combustion behavior of the solid porous burner. For the first step, the solid porous burner is examined based on the same feature described above-mentioned as defined by non-porous emitter case. For the second case, the stainless wire-net having PPI (Pores per inch) of 12 and thickness (H_{PE}) of 3 mm is installed top of horizontal chamber or higher the combustion zone. The improved wire-net become porous emitter leading to the second experiment is called as porous emitter case.

The experimental condition of the present study consisting of three mass fuel rates (Q_F), i.e., 0.080, 0.096 and 0.116 kg/min, and four volume flow rates of air (Q_A: 10, 15, 20 and 25 m^3/hr). The combustion behavior of the solid porous burner are the temperature profile (T), exhaust gas (CO and NOx) and combustion efficiency (η_C). Therefore, fourteen thermocouples of N type are attached to measure the temperature (T) along the chamber length. The exhaust gases is monitor by Testo M350-Model and is reported in correction by 0% excess oxygen on dry basis. The combustion efficiency (η_C) is given by

$$\eta_C = \frac{E_F - E_U - E_{CO}}{E_F} x100\% \quad (1)$$