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Emissions from multiple-spouted and spout-fluid fluidized beds using rice husks as fuel

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Abstract

This paper presents the experimental results of the emissions of CO and CO_2 using rice husks as fuel on different configurations of spout-sluidized beds namely, multiple-spouted and spout-fluid fluidized bed. The emission of pollutants from the multiple-spouted bed and spout-fluid bed was investigated with rice husk fuel. The operating parameters considered were the different levels of excess air, different primary-to-secondary air ratios at each level of excess air and method of feeding. It was found that emission of CO from the multiple-spouted bed seemed to be lower with under-bed feeding of the rice husk fuel compared to over-bed feeding. However, the emission of CO_2 did not change significantly for both methods of feeding. Changes in excess air levels influenced the emissions of CO and CO_2 from the multiple-spouted bed within the excess air range investigated. It was found that emission of CO was less at 10% excess air with over-bed feeding; emission of CO in the case of under-bed feeding was lowest at 20% excess air level. It was found that the method of feeding had not significantly influenced the emission of CO and CO_2 in the spout-fluid bed. The combustion efficiency however, in general, was slightly higher in the case of under-bed feeding compared to over-bed feeding. Emission of CO was less in the spout-fluid bed compared with the emission of CO in the multiple-spouted bed. The result can be likely attributed to the higher combustion efficiency attained by the spout-fluid bed compared with that of multiple-spouted bed.

Keywords: Rice husk combustion; Biomass combustion; Spouted bed; Spout-fluid bed; Emission; Fluidized bed

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1. Introduction

Massive demand for energy put pressure on our finite energy sources and the consequent environmental degradation as a result of the extraction, and use of these resources has compelled us to sharply focus our attention on the need for additional source of clean energy sources. Presently, there is a global consensus to address global warming and consequently climate change— and that countries are urged industrial or developing— to mitigate emissions of greenhouse gases. One of the several ways is fuel substitution of greenhouse-gas-producing fuels by a carbon-neutral fuel. Among the energy sources that can substitute fossil fuels, biomass fuels appear as the option with the highest worldwide potential. Biomass is an abundant energy source providing about 15% of the world's energy requirement [1], rice husk being one of the most abundant biomass energy residues.

The primary advantage of rice husk as a source of energy is its availability. Large quantities of rice husk are generated annually as a major by-product in the rice milling industry. The estimated worldwide rice husk production per year is about 100 million tons, 90% of which are generated in the developing countries [2]. The use of rice husk also reduces the environmental problems otherwise created by storing big volumes of it in the compounds of the rice mills.

Fluidized bed combustion technology has proven to be a suitable technology for converting a wide range of agricultural residues into energy due to its inherent advantages of fuel flexibility, low operating temperature and isothermal operating condition [3]. Several authors have studied the fluidized-bed combustion of rice husk, however, there is not enough information available about the pollutant emission in the present literature [4,5].

This paper presents the experimental results in particular, the emissions of CO and CO_2 using rice husks as fuel on different configurations of spout-fluidized beds namely: multiple-spouted and spout-fluid fluidized bed and the feasibility of burning rice husk in these different configurations.

2. Experimental set-up and procedure

2.1. Experimental set-up

Fig. 1 shows a schematic diagram of the fluidized bed constructed at the Energy Park of Asian Institute of Technology. The experimental system consisted of the combustor body, fuel feeding system, cyclone arrangement, temperature and pressure probes, the air supply and air distributor.

The combustor body was made of 3.4-mm thick mild steel with a cross-sectional area of $0.49\,m^2$ ($0.7\,m \times 0.7\,m$). The combustor consisted of two parts, the lower part (bed section) and the freeboard section. To reduce heat losses through the wall and protection against deformation due to thermal stress, thermal insulation was provided on the wall of the combustor using firebricks and castable materials for high-temperature applications.

The fuel feeding section consisted of fuel hoppers and screw feeders driven by a 1.5 kW electric motor through a pulley–belt system; under-bed and over-bed screw feeders were provided for under-bed feeding and over-bed feeding, respectively. K-type (Chromel–Alumel) thermocouples were installed for continuous measurement of temperatures at