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An investigation in 20 kW_{th} oxygen-enriched bubbling fluidized bed combustor using coal and biomass

Rajesh Kumar *, Ravi Inder Singh

Department of Mechanical Engineering, Birla Institute of Technology and Science, Pilani, Rajasthan, India

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ABSTRACT

The current article presents the experimental finding of co-firing coal with biomass under air-fired and oxygen-enriched conditions in a 20 kW bubbling fluidized bed (BFB). For the same, rice husk (RH), *Prosopis juliflora* (PJ), pine needles (PN) and plant litter (PL) are used as biomass alongside the coal. The bounteous accessibility of biomass in Northern region of India is the primary explanations behind its choice. The best possible usage of these biomass can possibly fortify the economy and additionally decreases the pollution. The experimental results show that the coal-biomass blend burns successfully inside the combustor, and the maximum temperature observed in the splash zone. A maximum conceivable combustion efficiency of 97.09% is accomplished with 75%coal/25%PJ under oxygen-enriched condition. The measured percentage of NO_x, CO_2 and other gasses is highly influenced by oxygen intake. The energy consumption, exergy destruction, and exergy efficiency are also assessed for fuels used. Exergy efficiency is varying from 30% to 58% for all the cases. The effect of particle size distribution on combustion efficiency is additionally studied. Among the four biomass fuels tested, PJ and PN have the best execution in co-firing mode.

1. Introduction

Fluidized beds are mostly preferred due to their excellent thermal and mixing properties [1] whereas, oxygen-enriched (air enriched with oxygen, O_2/N_2 mode) and oxy-combustion (O_2/CO_2 mode and O2/RFG mode) fluidized beds are the latest technologies proposed by many researchers to provide clean energy. India, being a developing country has an enormous demand for the clean energy to meet the future requirements. As an objective to provide the electricity access to each individual in the nation, fuel security and healthy environment, it is essential to investigate the renewable energy resources. Biomass like agricultural waste, organic matter, forest waste, and so on are available bounteously within the nation.

Co-firing of coal with biomass can be an attractive approach to increase the share of renewable energy resource and reduce the dependency on fossil fuel that further contributes to the sustainability of the natural resources [2]. Co-firing biomass with coal either in oxygen-enriched or oxy-combustion fluidized bed provides the dual benefits; the first benefit of biomass is as a renewable energy resource and secondly it provides the most favorable environments for the combustion of solid fuels. It has a potential for negative CO_2 emission level for power generation [3,4] as biomass combustion is considered to zero greenhouse emission in air firing mode. Jia et al. [5,6], Krzywański et al. [7], Guedea et al. [8] and Czakiert et al. [9] investigated the fluidized bed combustor under oxygen-enriched and oxy-combustion conditions experimentally, where the artificial neural network (ANN) approach is introduced for the same conditions by Krzywanski et al. [10–12], which may overcome the shortcomings of experimental procedures. However, oxygen-enriched or oxy-combustion technology is still not applied commercially for CO_2 capture [13]. Few author examined the biomass as a fuel instead of coal (Singh et al. [14] agro-residues, Singh et al. [15] rice husk, Tzamtzis et al. [16] pine needles, Font et al. [17] pine needles and cones, Krzywanski et al. [18,19] forest biomass, sunflower husk, and willow), but co-firing in fluidized bed for oxy-enriched or oxy-combustion conditions is not explored much. The behavior of many fuels is not understood for such conditions.

Pine needles are sort of biomass which are abundantly available in the North, India. Approximately 1500 square km pine forest is available in the state Himachal Pradesh, India and 3400 square km in the state Uttrakhand, India. As per the report [20] presented by the Ministry of New and Renewable Energy, Government of India in 2012, 1 m^2 of pine forest will yield 1.19 kg of pine needles every year and a 100 kW gasifier running for 24 h would require 4500 kg of pine needles. Highly inflammable and non-biodegradable pine needles are spread over the forest floor area that catches fire instantly in the summer due to high atmospheric temperature. The forest fire produced a higher gas emission and considerable damage to the economy and biodiversity. It is necessary to utilize these pine needles to make some valuable product, and one solution is to harness the energy from the same. *Prosopis juliflora*

* Corresponding author.
E-mail addresses: rajesh.narota@gmail.com (R. Kumar), dr.rjassar@gmail.com (R.I. Singh).

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