Performance Evaluation of a Horizontal Air Staged Inclined Biomass-to-Heat Energy Converter for Drying Paper Egg Trays

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Abstract- This study presents the performance evaluation of a horizontal air staged inclined biomass-to-heat energy (B2H) converter used for drying purposes in the production of paper egg-trays. The thermal properties and moisture content of the selected biomass such as oil palm kernel shell and wood chips were assessed. The influence of air mixture ratio (AMR) on temperature profile, flue gases composition and combustion efficiency of the selected biomass were determined with a Testo 350XL flue gas analyser. It was observed that an increase in AMR led to an increase in the average temperature of the pyrolytic chamber but decreased the average temperature of the exhaust, with insignificant change in the surrounding temperature. CO, H_2, NO_x and SO_2 concentrations were inversely proportional to an increase in AMR and an increase in oxygen content in the B2H converter exhaust. Combustion efficiency of the B2H converter was inversely proportional to an increase in AMR. Combustion efficiency of 67.00 ± 0.34 % was achieved with Experiment vii. CO and NO_x emissions at the B2H exhaust (Experiment-vii) met the EPA regulations, that is, 193.35 ± 9.17 ppmv and 9.20 ± 0.87 ppmv, respectively. SO_2 emission at the B2H exhaust, however, was lower than the NIOSH regulations, that is, 4.57 ± 1.08 ppmv. Thus the B2H converter demonstrated that CO, NO_x and SO_2 emissions can be significantly reduced with oil palm kernel shell and wood chips.

Keywords- Biomass, Gas emission, Combustion, Performance evaluation.

1. Introduction

Malaysia is the world's largest producer and exporter of palm oil and its products. Palm oil production increased from 2.5 million tonnes in 1980 to 17.8 million tonnes in 2009 [1]. Co-products such as fronds, trunks, empty fruit bunch (EFB), palm fibre and shell are not utilized, however. Wood waste in Malaysia found in the logging industries in 2009 alone gave a total production of logs based on the total land area of 18.27 million m^3 [2]. From January to February 2009, Malaysia generated a free on board (FOB) value of more than RM 202 million through logging activities [3]. This generated a huge amount of wood waste, which can potentially give rise to environmentally sensitive disposal issues.

It is known that biomass is most cost-effective for heat production for low carbon taxes (below 50 to 100 USD/Toricredits) [4]. Various types of biomass combustor are currently available such as updraft, downdraft, cross-draft, fluidized-bed design features and others [5].