A Study of Oxy-Combustion of Palm Empty Fruit Bunch with Coal

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Abstract

Biomass has the advantage of net zero carbon emissions and can even achieve negative carbon emission using oxy-fuel combustion with CO_2 capture. More than ten million tons of Palm Empty Fruit Bunches (PEFB) annually produce in Indonesia and Malaysia as agricultural residues, which can be used as biofuel. Co-combustion of Palm empty fruit bunches (PEFB) and coal can make up for the adverse effects of high pollutant and high ash content of coal. Oxy-fuel combustion and CO_2 capture from flue gases is a near-zero emission technology that can be adapted to both new and existing pulverized coal-fired power stations. In this study, the combustion characteristics of PEFB, Australian coal and their blend with various blending ratios are investigated. First, the feedstock is analyzed via proximate analysis, elemental analysis and calorimetry. The pyrolysis and combustion behavior of PEFB in the air and Oxy-fuel conditions are then investigated by thermogravimetric analysis (TGA). The combustion characteristic parameters (ignition temperature, burnout temperature and the comprehensive combustion characteristic index) are calculated from the TGA results and the synergistic effects of blends with various blending ratios are also studied. Evolved species in the flue gas are analyzed through Fourier-transform infrared spectroscopy (FTIR Analysis). A single pellet free-drop furnace is also used to investigate fuel ignition delay, fuel combustion time and burning rate. The current results indicated that replacing N_2 by CO_2 in the combustion atmosphere with 21% of O_2 caused increase in the ignition temperature and burnout temperature. When the O_2 concentration was increased to 30%, the ignition temperature and burnout temperature were lower than the air case. A slight decrease in the ignition temperature and a significant reduction in the burnout temperature were observed after the addition of PEFB. This trend became more obvious as the blending ratio was increased. The emissions of NO_x and SO_2 during oxy-combustion were lower than under air-firing conditions. The reaction rate constant of combustion process calculated for 21%O_2/79%CO_2 was slightly lower than that for 21%O_2/79%N_2. There is a synergistic effect for the co-combustion of PEFB and Australian coal, especially in the char oxidation stage. Finally, after determining the appropriate blending ratio and oxy-fuel condition, oxy-combustion of PEFB and coal will be performed using a 280KW_{th} Pulverized-coal furnace.