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Experimental study of pulverized coal oxycombustion and modelling of devolatilization kinetics

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The combustion of coal which use is projected to increase by 25% from 2009 to 2020 leads to high CO_2 emissions that contribute to around 40% of the total quantity of greenhouse gases emitted into the atmosphere. Improving energy efficiency of combustion systems and using carbon capture and storage (CCS) techniques are thus recommended to reduce such emissions. Oxy-fuel combustion of coal with recycled flue gases mainly composed of carbon dioxide appears to be one of the most promising CCS techniques to retrofit conventional power plants. It insures an increased concentration of CO_2 in the exhaust gases compared to standard air combustion. This CO_2 can thus be efficiently and economically captured to be valued or sequestered.

Combustion under such specific conditions has to be thoroughly understood, however, since both the O_2 concentration and the nature of the diluent are different from those met during conventional air combustion. Laboratory scale studies have thus been conducted during the last few years to analyze the fundamentals of oxy-coal combustion, a better understanding of the physical-chemical mechanisms involved in pulverized coal devolatilization and oxidation under oxygen enriched medium being necessary to understand the main trends observed during pilot-scale tests and to predict scale-up performance through CFD modelling.

In the present work, devolatilization kinetics of a pulverized high volatile bituminous coal has been measured experimentally and modeled in air and oxycombustion conditions. To do so, a new experimental test bench based on the use of a hybrid flat flame burner has been developed in our lab in order to stabilize coal jet flames with fuel heating rates similar to those found in industrial combustors. For each considered atmosphere, the char temperatures have been monitored by two-color infrared pyrometry as a function of the particles residence time derived from PIV measurements. Char samples at different residence times have been collected and analyzed to derive devolatilization profiles that have been compared with data issued from different kinetic models. Based on the obtained results, new sets of kinetic parameters have been derived to simulate the devolatilization of the studied pulverized coal under high heating rate (>10^6 K/s) with N_2- and CO_2- based atmospheres. Such a research strategy coupling experimental measurements and kinetic modelling should be of interest to improve the accuracy of CFD simulations integrating thoroughly obtained kinetic data.

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