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Challenges of oxyfuel combustion modeling for carbon capture

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From the policies scenario from Internal Energy Agency (IEA) in 2010, global energy demand for coal climbs from 26% in 2006 to 29% in 2030 and most of demands for coal comes from the power-generation sector [1]. According to the new Copenhagen protocol [3], Global CO_2 emission is rising from power generation due to an increasing world demand of electricity. For Energy-related CO_2 emission in 2009, 43% of CO_2 emissions from fuel combustion were produced from coal, 37% from oil and 20% from gas [4]. Therefore, CO_2 capture from coal is the key factor to reduce greenhouse gas emission.

Oxyfuel combustion is one of the promising technologies for capturing CO_2 from power plants and subsequent CO_2 transportation and storage in a depleted oil or gas field or saline-aquifer. The concept of Oxyfuel combustion is to remove N2 from the combustion process and burn the fuel with a mixture composed of O_2 and CO_2 together with recycled flue gas back into combustion chamber in order to produce a flue gas consisting mainly of CO_2. This flue gas can be easily purified, compressed and transported to storage sites. However, Oxyfuel plants are still in the phase of pilot-scaled projects [5] and combustion in Oxyfuel conditions must be further investigated for a scale-up plant.

Computational fluid dynamics (CFD) serves as an efficient tool for many years in Oxyfuel combustion researches [6-12] to provide predictions of temperature, heat transfer, and product species from combustion process inside furnace. However, an insight into mathematical models for Oxyfuel combustion is still restricted due to many unknown parameters such as devolatilization rate, reaction mechanisms of volatile reactions, turbulent gaseous combustion of volatile products, char heterogeneous reactions, radiation properties of gaseous mixtures and heat transfer inside and through furnace's wall. Heat transfer drastically changes due to an increasing proportion of H_2O and CO_2 in these Oxyfuel conditions and the degree of changes depends on the amount of both mentioned gases because both gases have higher thermal heat capacity than N2 in air-fired combustion processes and also are a good emitter and absorber of radiation [13-14].

The mentioned mathematical models are investigated using numerical CFD software (ANSYS FLUENT 12.0) [15] to provide predictions of aerodynamics, thermo-chemical and heat transfer quantities. The numerical models of lignite combustion under oxy-fuel conditions are first investigated in laboratory scaled furnace applying correlations for weighted sum of gray gases (WSGG) model for the predictions of radiation properties of oxy-fuel gas mixture [16]. The developed numerical models are further used for the predictions of temperature, hemi-spherical incident intensity and species concentrations (O_2, CO_2, H_2O) for a 0.4 MWth oxy-fuel furnace at BTU Cottbus.

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