Numerical simulations of oxy-coal combustion in Youngdong 100 MWe retrofit boiler

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Demonstration of oxy-coal combustion is being planned for the old Youngdong unit 1 boiler in South Korea. The boiler is to be retrofitted to an opposed-wall-firing type with 100 MWe capacity for demonstration of oxy-fuel combustion while maintaining the original furnace shape of downshot firing. It is to be operated under oxy-coal combustion mode during demonstration periods while continuing commercial operation under air-coal mode. Since the retrofit boiler has an unconventional furnace of a very wide burner zone followed by a narrow upper chamber, it is essential to evaluate the combustion and heat transfer characteristics in finalizing the detailed design. This study investigated the combustion and heat transfer under air- and oxy-fuel combustion in the Youngdong retrofit boiler using computational fluid dynamics. The boiler has 8 swirl burners each on the front and rear walls with overfire air used for the air-coal model. In the simulations, the rate of devolatilization and composition of volatiles released were determined by using FLASHCHAIN. The heterogeneous char reactions with O\textsubscript{2}, CO\textsubscript{2} and H\textsubscript{2}O were predicted by the unreacted-core shrinking model. Subsequent reactions in the gas phase were calculated for 8 global reactions of tar and other intermediate chemical species. The discrete ordinate method was applied for radiation with an advanced model for gas emissivity. The results show that the boiler achieved good combustion in both combustion modes for the sub-bituminous coal considered as design fuel. Although the burner zone has a large heat transfer area, the presence of refractory lining on the side wall was helpful in maintaining sufficiently high temperature to complete the char conversion. However, the contribution of gasification by CO\textsubscript{2} and H\textsubscript{2}O to char conversion was significantly high (40–46\%) in both combustion modes, due to the reduced mixing between O\textsubscript{2} and char in the wide burner zone. This trend in char conversion was different from a front-wall firing boiler with the same capacity, in which the char was converted mostly (80–90\%) by oxidation. Compared to the air-coal mode, the heat flux on the wall was about 6\% lower under the oxy-coal mode at 27 vol.\% of O\textsubscript{2} in the oxidizer. Local regions of very high heat flux need to be considered in further development of the process.

Keywords: Char combustion; Oxy-coal combustion; Opposed firing; Youngdong boiler; Wall heat flux