The Impact of Burner Staging on NO Reburning during Oxy-coal Combustion

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In order to meet obligations set by the Paris Climate Agreement ratified by over 150 countries, carbon capture and storage technologies must be utilised. Oxy-fuel combustion is believed to be the most techno-economically feasible carbon capture technique; this involves the combustion of fuel in an O2/CO2 oxidant created by combining recirculated flue gas with oxygen from an air separation unit. The resulting flue gas contains minimal nitrogen and a much greater CO2 concentration compared to air combustion, allowing for less complex and more economical CO2 separation and purification. Furthermore, a phenomenon occurs in the flame; where the NOx that is present in the recycled flue gas reacts with fuel fragments in reburn reactions. However, this does not eliminate the issue of pollutant formation and pollutant abatement technologies (such as SCR or sour gas compression for NOx removal) are still required to be installed in order to achieve near-zero emissions. Along with other costly unit operations, such as the air separation unit, can severely impact the process economics of oxy-fuel power generation. Therefore reducing pollutant formation and maximising combustion efficiency is of great importance to the technological progression of oxy-fuel combustion.

This study presents the effect of varying the stoichiometry in the fuel rich region and the overall swirl of an oxy-coal flame on the rate of the inherent NOx destruction processes. The data was gathered from the 250 kWth down-fired combustion test facility at the pilot-scale advanced CO2 capture technology centre (PACT) at the University of Sheffield utilising a scaled-down industrial low-NOx burner. Measurements were taken in air and oxy-coal combustion environments varying concentrations of simulated recycled NOx. The industrial low-NOx burner allowed for the variation of secondary and tertiary oxidant flows, while maintaining the primary and total excess oxidant, in order to optimise the flame for low NOx emissions and high carbon burnout while maintaining flame stability.

The flow split between the secondary and tertiary streams was extensively investigated by monitoring emissions (O2, CO2, CO, NOx, THC) in the flue gas, as well as down the centre-line of the furnace and in-flame radial profiles, in order to examine the impacts on NOx formation and reburning. This investigation finds that 85 % to 99 % of the recycled NO is destroyed at a range of burner configurations for OF 27 and OF 30 at 170 kWth. In addition to this, NO formation and carbon burnout are found to be significantly affected with changing burner configuration. The axial and radial profiles appear to show that burner staging aids in controlling the products of NO reburning, hence maximising the destruction of recycled NO. The study's aim is to aid predictability for operators, in addition to providing greater understanding of the NOx destruction processes and an abundance of experimental trends to aid modellers.

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