

Stability and Heat Radiation Properties Methane Flames in CO₂ Diluted Oxy-Fuel Atmospheres

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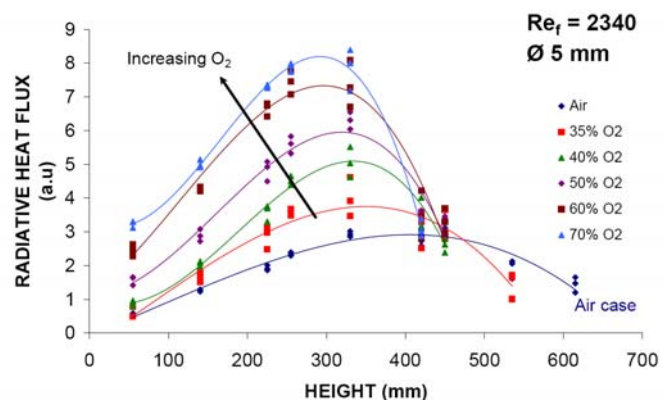
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ABSTRACT

The oxyfuel concept is a promising technology for CO₂ capture since the ideal combustion of a stoichiometric mixture of hydrocarbons and oxygen theoretically results in a flue gas consisting solely of the combustion products H₂O and CO₂. In order to lower the extremely high temperatures associated with stoichiometric oxygen combustion, a part of the CO₂ stream is recycled. The presence of variable concentration of CO₂ in the oxidant has strong effects on the combustion characteristics. This article focuses on the one hand on the heat radiative properties of methane flames in oxy-fuel atmospheres, on the other hand on nozzle stability (lift off and blow out behaviours). The scope of the experimental study covers oxidant compositions of CO₂/O₂ with O₂ concentration from 30% to 70%. In addition we always use the same flames in air condition as a reference, as an indication of the level of change the actual combustion systems have to cope with.

Axial flame heat flux profiles at $Re = 2340$ at different oxidant compositions (Figure 1) shows that the near field radiative properties are very dependent on O₂ and CO₂. Both the total heat flux radiated and peak value position is influenced. The flame shortens as O₂ increases as a consequence of variation in stoichiometric mixture fraction. The higher intensity of the heat flux can be explained partly by the increase in temperature, but also by the



increases of the concentration of radiating gas and soot volume fraction. In the far field, the heat flux reaches the same levels for all flames. It is known that the increased local soot volume fraction accompanying an increase in oxygen concentration is compensated by an increased oxidation rate of soot downstream the flame, attaining global soot levels that are in fact lower than in the air case. The lift-off and blow-out characteristics of the flame are very affected by the concentration in O₂ in the atmosphere, as a result of direct changes on local temperature and laminar flame speed. However, by comparing the results with the case where CO₂ is replaced by N₂, we observe that the radiative properties of CO₂ have also an influence on the stability behaviour. Indeed, the onset of lift-off and the lift off height itself is not only dependent on the exit velocity, but also very sensitive to temperature in the chamber.

The present experimental study highlights important differences in the flame characteristics as a function of atmosphere compositions that can be met in CCS processes based on the oxy-fuel alternative.

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Proposed Topic: Combustion