Packed-bed chemical-looping combustion : theoretical investigation and experimental validation

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(24c) Packed-Bed Chemical-Looping Combustion: Theoretical Investigation and Experimental Validation

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Chemical looping combustion in dynamically operated packed bed reactors has been investigated both theoretically and experimentally. The effects of operating temperature, feed oxygen concentration, steam addition and type of oxygen carrier material on the process performance have been evaluated, with detailed models and with dedicated experiments.

The prevailing phenomena during reduction and oxidation cycles that the oxygen carrier particles undergo in Chemical Looping Combustion processes have been studied in great depth using an advanced numerical model in which the effects of reaction kinetics and internal and external mass and heat transfer processes were incorporated in detail. The particle model was validated through TGA experiments carried out on different oxygen carriers at different operating conditions. With the validated model, improved understanding of the effect of mass and heat transfer processes on the rate at which oxygen carriers are reduced and oxidized has been obtained, in particular the effect of drift fluxes, which is essential for an accurate prediction of the performance of packed-bed CLC processes at larger scales.

Subsequently, a combined reactor and particle model was developed with which the effect of mass and heat transfer limitations inside the oxygen carrier particles on the axial concentration and temperature profiles in packed-bed CLC can be properly accounted for. The model was validated via experiments carried out in a lab-scale dynamically operated packed bed for CLC of methane. Conversion and selectivities during both oxidation and reduction cycles along with the axial temperature profiles in the bed have been evaluated and compared with modeling results.

With these models, more reliable predictions of the axial concentration and temperature profiles in packed-bed CLC can be given, which are necessary to arrive at a proper design and a quantitative assessment of the techno-economical viability of packed-bed CLC.

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