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Investigation of the process operability windows for Ca-Cu looping for hydrogen production with CO_2 capture

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HIGHLIGHTS

- The Ca-Cu process was described in detail with a 1-D pseudo-homogeneous model.
- A simplified model based on a sharp front approach was developed.
- Operating windows for the three process steps have been identified.
- Thermal efficiency and carbon capture efficiency of the Ca-Cu process have been calculated.

ABSTRACT:

The calcium-copper looping process is a novel concept proposed for hydrogen production from methane with integrated CO2 capture. The heat required to drive the endothermic steam-methane reforming is supplied by in-situ simultaneous heat production from calcium carbonate formation, by which also CO2 capture is achieved (calcium looping process). In the regeneration step, the heat required to regenerate the CO2 sorbent is matched with in situ heat production through the reduction of copper oxide to copper (chemical looping process). The process is carried out in adiabatic fixed bed reactors and consists of three main process steps: (i) sorption enhanced reforming, (ii) oxidation of copper and (iii) calcination of CaCO3 combined with the reduction of CuO. In this paper the process has been simulated in detail with a one-dimensional pseudo-homogeneous reactor model (PHM) and a reduced model has been developed (computationally enormously much faster and still sufficiently accurate) based on a sharp front approach to

simplify further reactor and process design and optimization. Simulations with the PHM have been performed for the three steps of the process varying the temperature, pressure, solid composition, gas composition and flow rates. The outcomes of the model have been compared with calculations performed with the sharp-front approach. The reaction and heat exchange front velocities calculated with both models are in very good agreement. Process operability windows for all three process steps have been identified. The overall thermal efficiency and the carbon capture efficiency have been calculated, resulting in 73% and 80%, respectively.