Chemical Looping Combustion power generation and H_2 production with CO₂ capture

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What are the advantages?

- No sorbent required
- No ASU required
- High fuel conversions (≈ 100 %) achievable
- Applicable for range of fuel types



CLC with H₂ production and Power Generation



Flowsheeting of a CLC Process with H₂ Production and Power Generation

Process Flowsheet



Solving of Flowsheet

- Modelled in MATLAB
 - Thermodynamic data from NASA-Glenn database
 - Reactions solved by Gibbs Energy minimisation
- Two key system variables
 - Iron oxide circulation rate n_{Fe}
 - Steam flowrate into OX1 n_{st}

Heat Integration



Suitable Operating Regime







Enhancing oxygen carrier performance with Al_2O_3 support

Al_2O_3 as a support material



Fe-Al-O phase diagram



Effect of Fe-Al-O phase equilibrium on H₂ production



Oxygen carrier particle after cycling



75 wt% Fe₂O₃, 25 wt% Al₂O₃ after 20 cycles, sectioned

(red = Feyellow = Al)

Conclusions

- CLC has high potential for highly efficient CO₂ capture with both power generation and H₂ production
- Can be optimised towards producing electrical power/ H_2
- Oxygen carrier support material (such as Al_2O_3) essential for long-term performance
 - Interaction between reactive and support material must be fully understood.

Related Publications

- J.P.E. Cleeton, S.A. Scott & J.S. Dennis. Interaction between Fe-based oxygen carriers and volatile hydrocarbons during Chemical Looping. Submitted to Appl Energ (2011)
- P.R. Kidambi, J.P.E. Cleeton, J.S. Dennis, S.A. Scott & C.D. Bohn, The interaction of iron oxide with alumina within a composite oxygen carrier during the production of hydrogen by chemical looping. Submitted to Energy Fuels (2011)
- C.D. Bohn, J.P.E. Cleeton., C.R. Müller, J.F. Davidson, A.N. Hayhurst, S.A. Scott & J.S. Dennis, The kinetics of the reduction of iron oxide by carbon monoxide mixed with carbon dioxide. AIChE J. 56(4) (2010) pp 1016-1029.
- J.P.E. Cleeton, C.D. Bohn, C.R. Müller, J.S. Dennis & S.A. Scott, Different Methods of Manufacturing Fe-Based Oxygen Carrier Particles for Reforming Via Chemical Looping, and Their Effect on Performance, Proceedings of 20th International Conference on Fluidised Bed Combustion (4) (2010) pp 505-511
- C.D. Bohn, J.P.E. Cleeton, C.R. Muller, S.A. Scott & J.S. Dennis. Stabilising iron oxide used in cycles of reduction and oxidation for hydrogen production. Energy Fuels. 24(7) (2010) pp 4025–4033
- J.P.E. Cleeton, C.D. Bohn, C.R. Müller, J.S. Dennis & S.A. Scott, Clean hydrogen production and electricity from coal via chemical looping: Identifying a suitable operating regime, Int J Hydrogen Energ 34(1) (2009) pp 1-12

Thank you Any questions?

Phase diagram



Hydrogen Production



Units denote mol H₂/s/kg fuel