Design of a 300 kW$_{th}$ indirectly heated carbonate looping test facility

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Outline

• Introduction

• Thermodynamic process evaluation

• Setup of 300 kW$_{th}$ test facility

• Cold flow model testing

• Conclusions
Introduction – Process Scheme

- No oxygen for calciner → **high plant efficiency**.
- Bubbling bed calciner → **low sorbent attrition**
- „Mild“ heating → **low sorbent deactivation rates**
- No coal in calciner → **few additional impurities** (sulfur, ash)
- Almost **pure CO₂** stream at calciner exit

**Standard carbonate looping**
• Process simulations for various scenarios using ASPEN PLUS™
• Indirectly heated process most appropriate for new built plant (due to plant size)
• Efficiency for indirectly heated process (>1 % point) higher than for standard CL
Setup 300 kW\textsubscript{th} Test Facility

Carbonator:
- 300 kW\textsubscript{th} flue gas
- (~ 2.3 kmol/h CO\textsubscript{2})
- d = 0.25 m
- h = 8 m
- \(\dot{m}_{(CaO,CaCO_3)} \approx 1000\) kg/h

Calciner:
- Heat duty: 178 KW
- Number of HP`s: 72
- w = 0.3 m
- d = 1.25 m
- h = 2.7 m
- \(\dot{m}_{CO_2} = 82\) kg/h

Combustor:
- Thermal power ~ 310 kW
- Dimensions as in calciner
Design of Heat Exchanger

- Refractory lining
- Integrated cyclone (steel)
- Calciner
- Combustor
- Fluidization nozzles
Heat Pipe Heat Exchanger

- 72 heat pipes (2.2 m length)
- 1.6 m height of heat pipe package (2.7 m total reactor height)
- 3 refractory concrete supports

Source: FAU Erlangen-Nürnberg
Scaled Cold Flow Model

Objectives:

• Proof of concept
• Mass transfer and pressure measurements
• Specific solids flux investigations through the heat pipe package

Calciner model:

• Linear scaling (L.R. Glicksman)
• Viscous limit scaling
• Low particle-Reynolds-numbers in BFB
• Viscous forces dominate interphase drag
• Solid-to-gas density ratio is less important
• Scaling factor 90/250
• 72 heat pipes
Scaled Cold Flow Model

• Cold flow model tests proved coupling concept of reactors.
Cold Flow Model

Design of calciner and combustor:

Scaled cold flow model:

Measured solids flux:

- Cold flow model tests proved that solids flux through calciner is reached by low fluidization velocities.
Outlook

• Components of 300 kW<sub>th</sub> test rig ready to be manufactured
  • Contracts with suppliers are already placed

• Serial production for the heat pipes is running → All 72 heat pipes will be finalized till October 13

• Manufacturing of the reactors will be finalized till beginning of 2014

• Commissioning will be finalized till June 2014

• First test campaign is expected for July 2014
Conclusion

• Retrofit of the indirectly heated carbonate looping process is generally possible but causes big plant sizes

• New built construction with thermal integration is more applicable due to a reduced plant size and high efficiency

• Pressure characteristics of cold flow model successfully confirm the coupling concept of the planned test facility

• Solid flux investigations showed that the heat pipes are not significantly influence the particle flow through the calciner and the required solids mass flow through the reactor can be achieved

• 300 kW_{th} test rig is designed and will start operation mid of 2014
RFCS Project CARINA – Carbon Capture by means of an Indirectly Heated Carbonate Looping Process
Thank you for your attention!

Thermodynamic Evaluation and Cold Flow Model Testing of an Indirectly Heated Carbonate Looping Process