Fluidization XVII

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Edinburgh, Scotland, United Kingdom
May 21st – 25th , 2023

Performance of a limestone-based coupled fluidized bed reactor system aiming CO_2 capture in a 300 kW_{th} pilot plant

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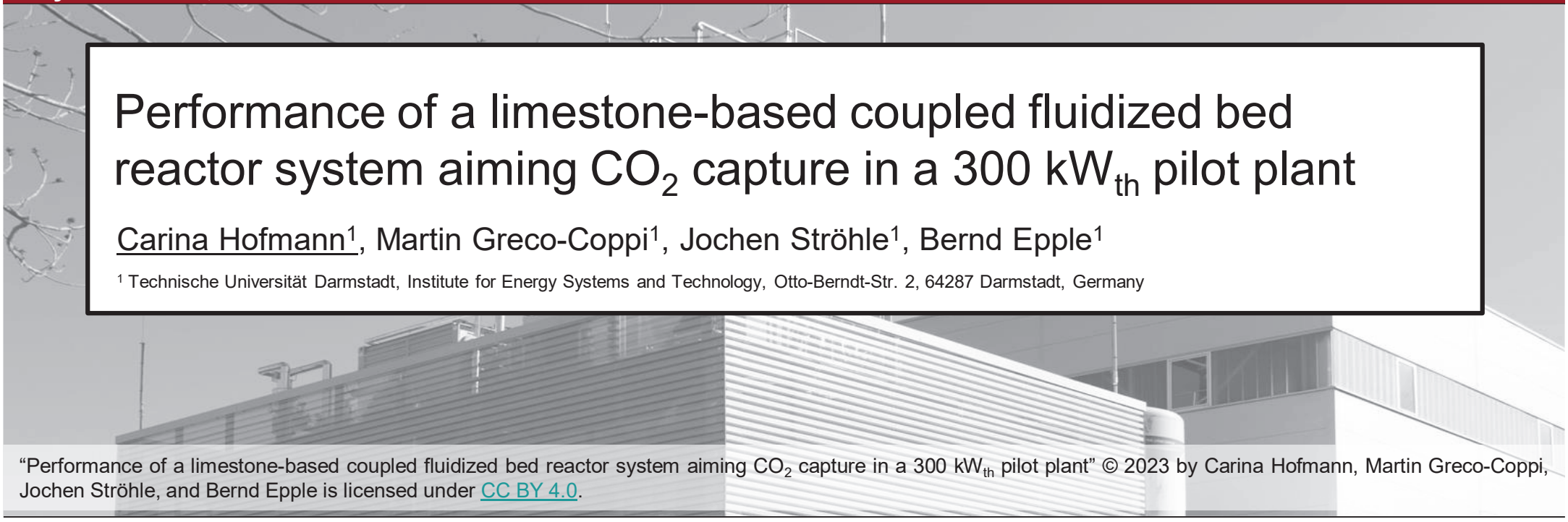
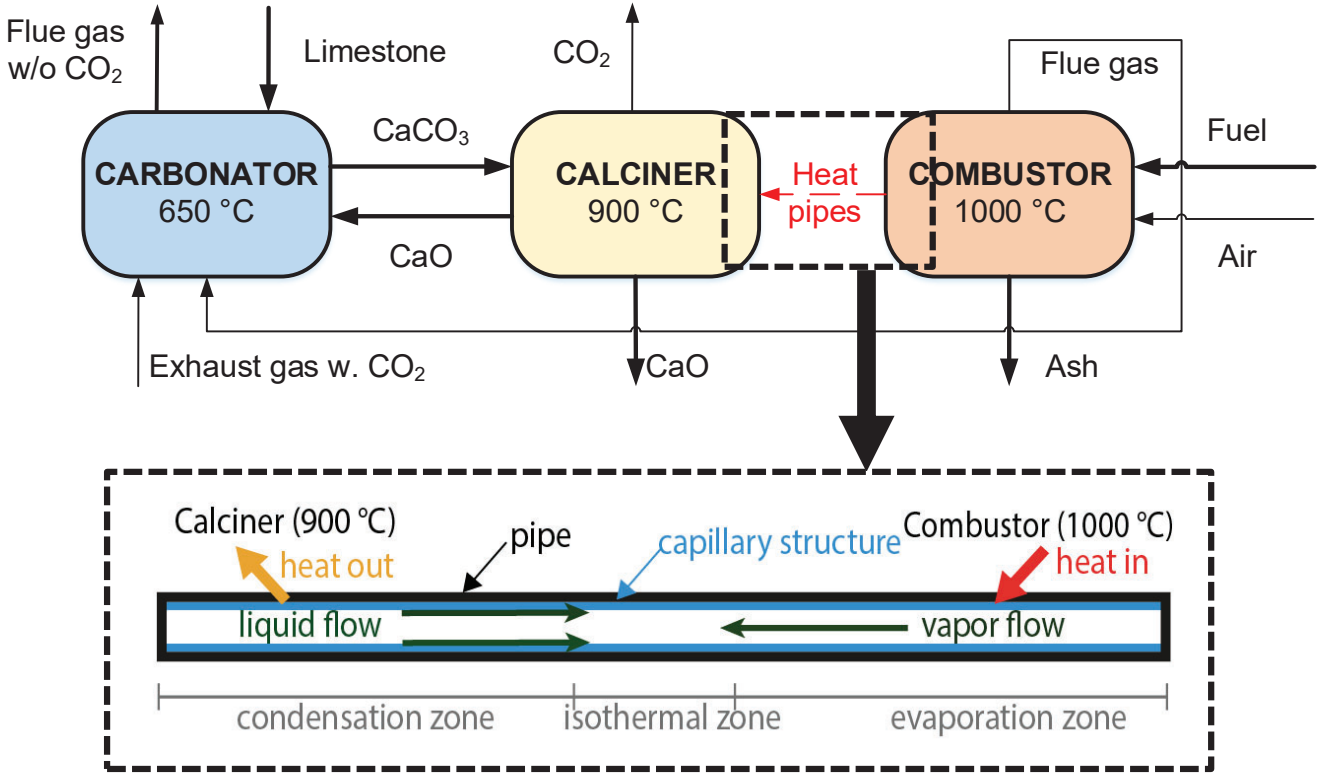


1 Introduction, Process Scheme Indirectly heated CaL

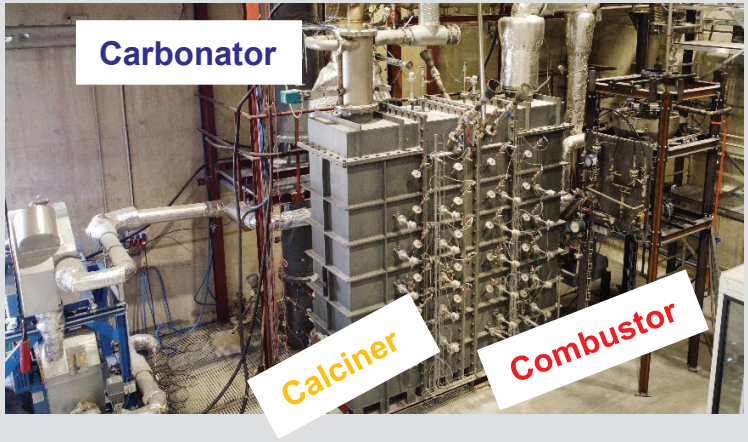


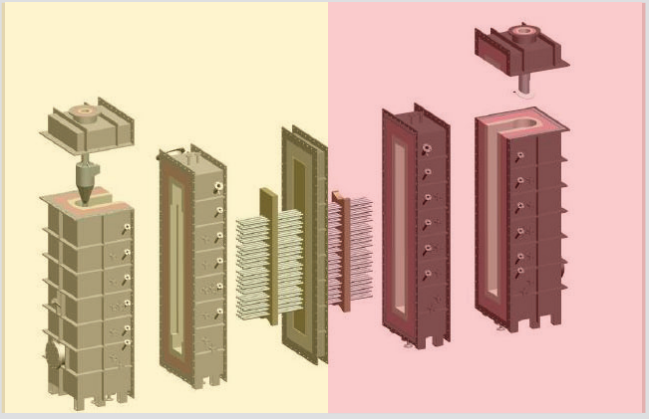
Indirectly heated Carbonate Looping

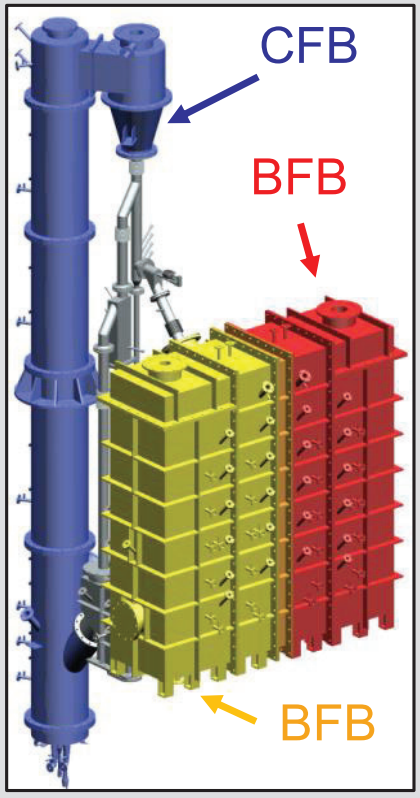
- **No air separation unit** is necessary
- **Few impurities** (sulfur, ash)
- **Synergies** with cement & lime

2 Experimental Reactors 300 kW_{th} Pilot Plant

	Carbonator	Calciner/ Combustor
Inner Diameter/ L x W	⌀ 0.25 m	1.1 x 0.3 m
Outer Diameter/ L x W	⌀ 0.6 m	1.4 x 0.9 m
Height	8 m	2.6 m

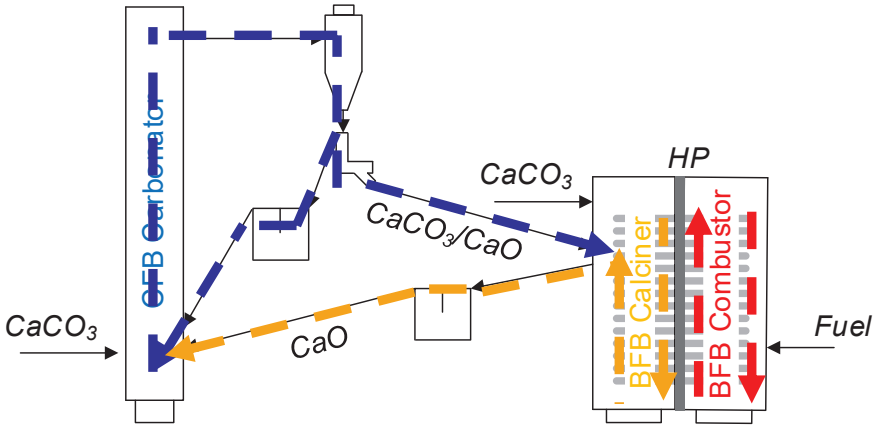




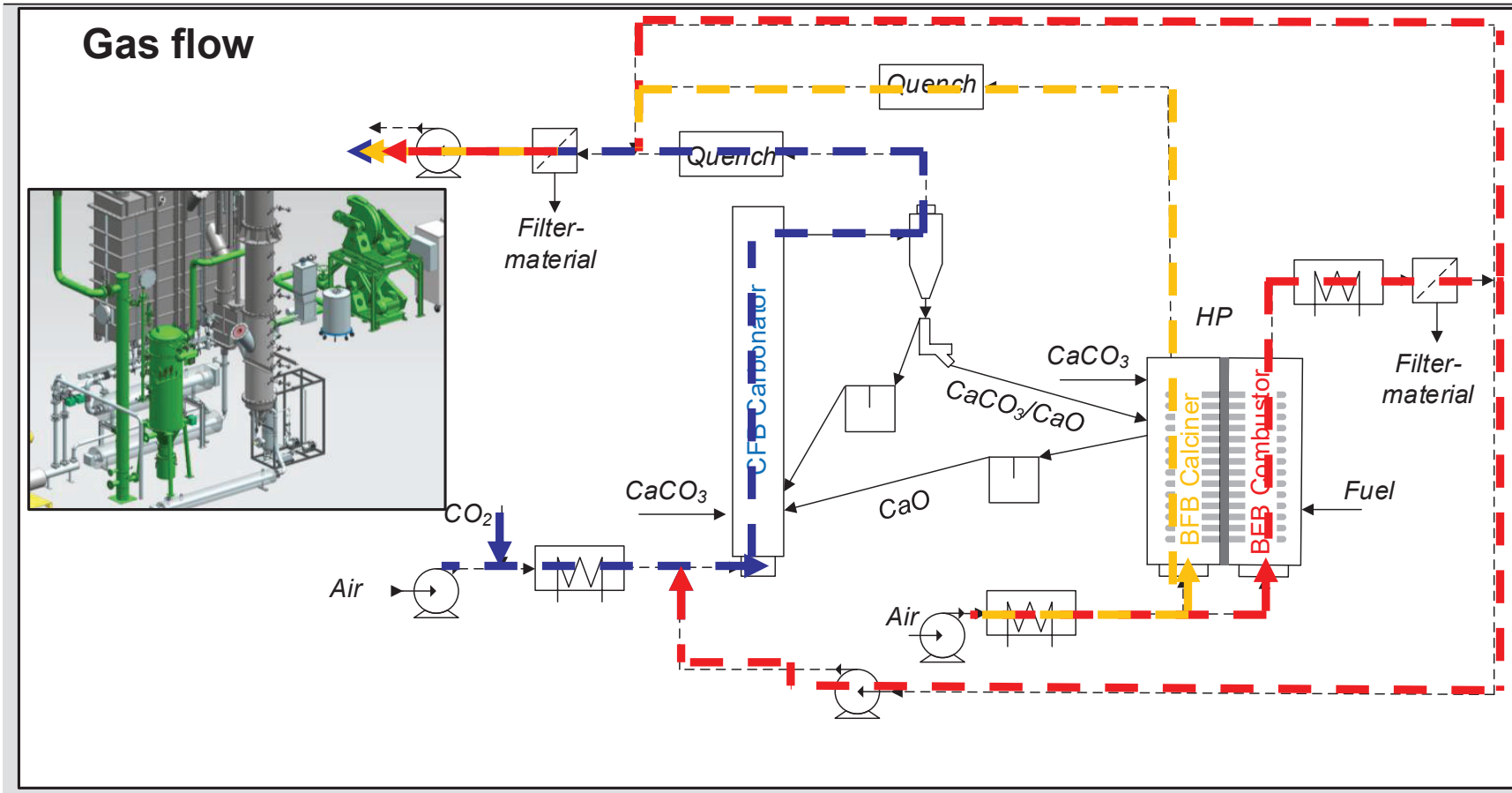


2 Experimental IHCaL Configuration (I)

Solid flow



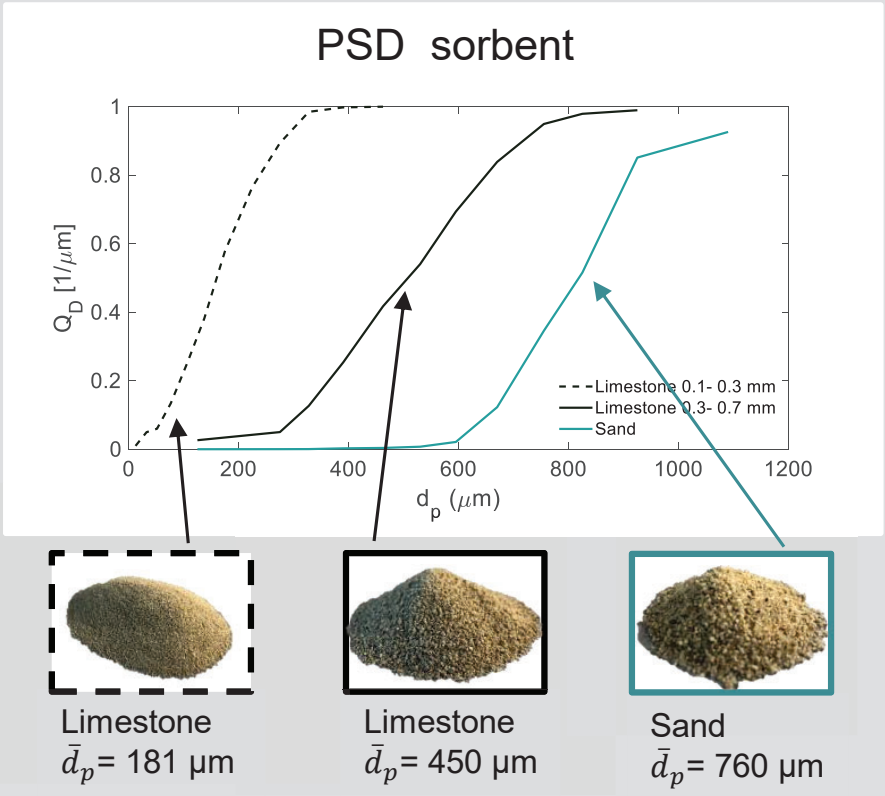
2 Experimental IHCaL Configuration (II)



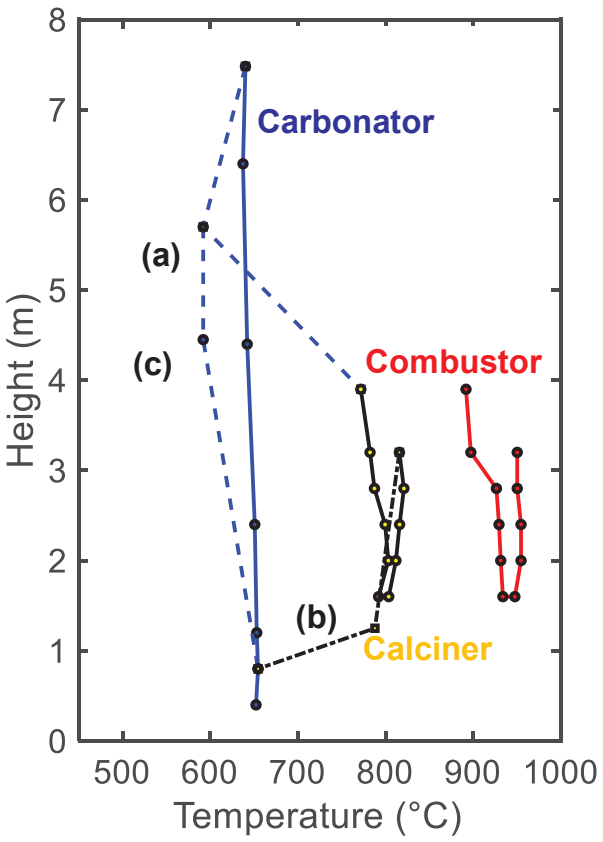
2 Experimental Range

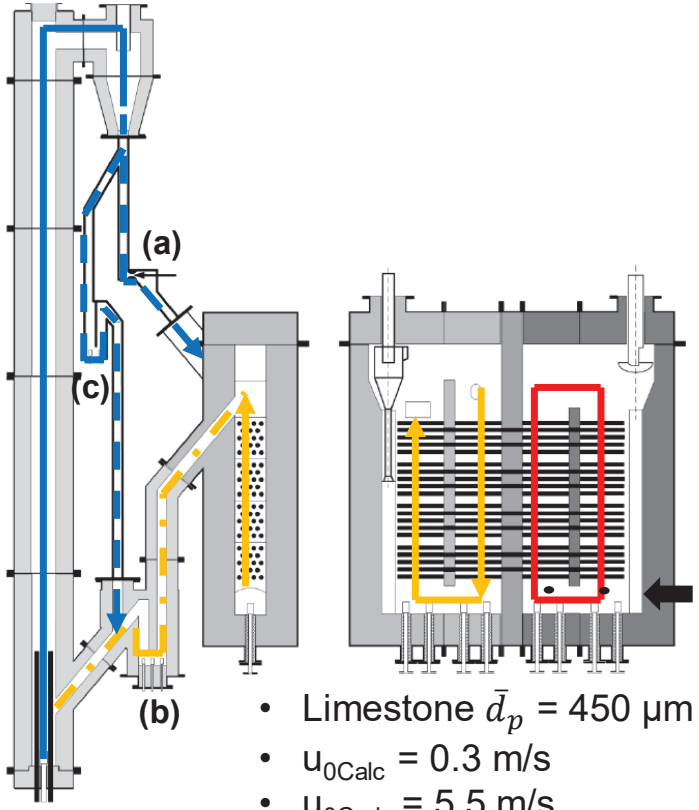
- 300 h of operation in CO_2-capture mode
  - ➢ 24 h with co-firing lignite
  - ➢ 24 h with co-firing waste derived fuels
- Two different sorbents applied
- Decarbonization of real flue gas in carbonator

Variable		Unit	Range		
			Calciner	Carbonator	Combustor
T	Temperature	°C	750 - 900	500-680	820-950
W_s	Specific inventory	kg/m²	1000-1600	200-1000	1000-1600
$u_{0,out}$	Superficial velocity	m/s	0.2-0.4	3.5-5.5	1.2-1.75
$\dot{Q}_{th}$	Thermal load	kW_{th}	50-200	-	200-365

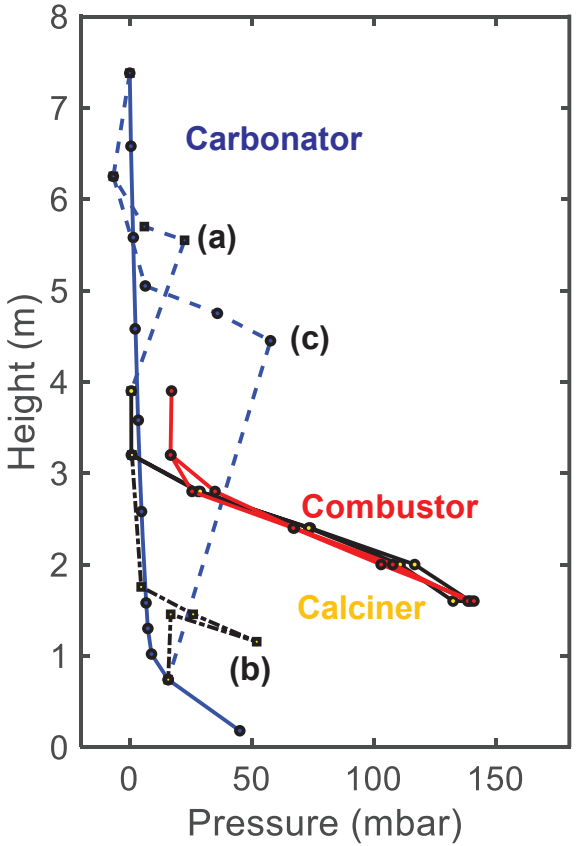


3 Results (I), Reactor Temperature & Pressure Profile

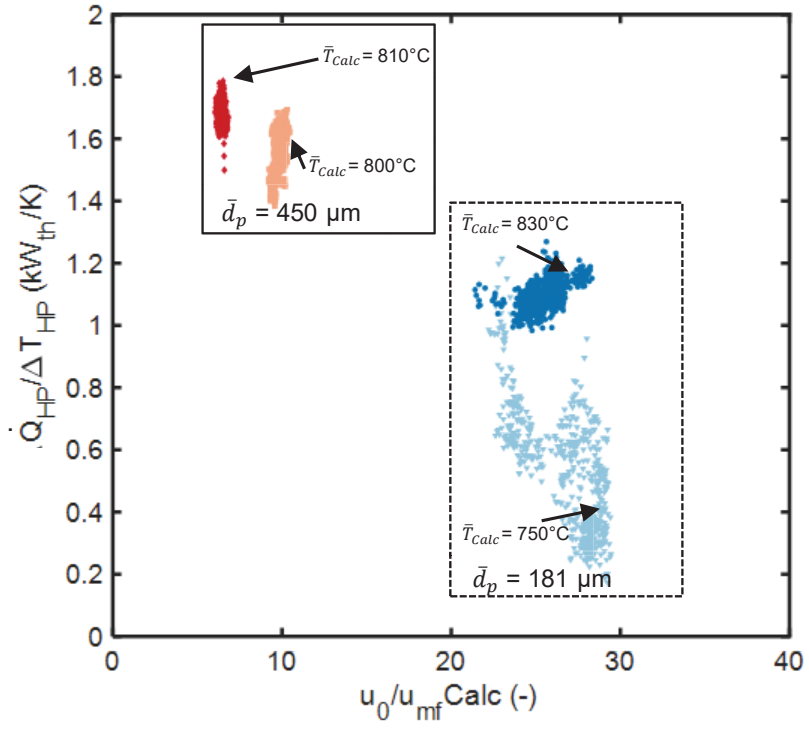




- Limestone $\bar{d}_p$ = 450 µm
- u_{0Calc} = 0.3 m/s
- u_{0Carb} = 5.5 m/s



3 Results (II), Heat Pipe Heat Exchanger Performance



$$\bar{\alpha}_{HP} A_{HP} = \dot{Q}_{HP} / (\bar{T}_{Comb} - \bar{T}_{Calc}) \quad (kW_{th}/K)$$

Performance is mainly limited by heat transfer between bed and heat pipes

- Low fluidization numbers and small particles favorable for heat transfer
- Expected max. heat transfer close to u_{mf} [1]
- u_{0min}=0.2 m/s due to CO_2 release

➢ In pilot plant impact of optimal fluidization dominant

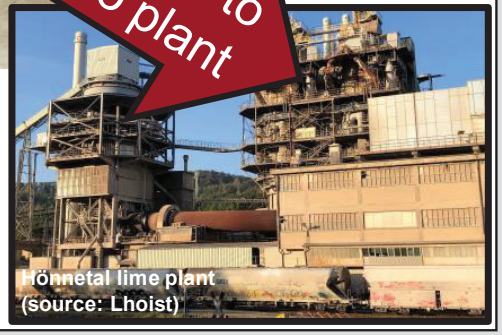
➢ Other dependency needed to be considered

➢ Further assessment and parameter study necessary

[1] Martin,1980

4 Summary & Outlook

- Limestone of high Geldart B class most suitable for the IHCaL- facility
- Stable hydrodynamics achieved
- First operation with solid fuels



Outlook

- Further pilot testing of operational behavior

➢ Up-scaling to demo-plant size

Acknowledgement

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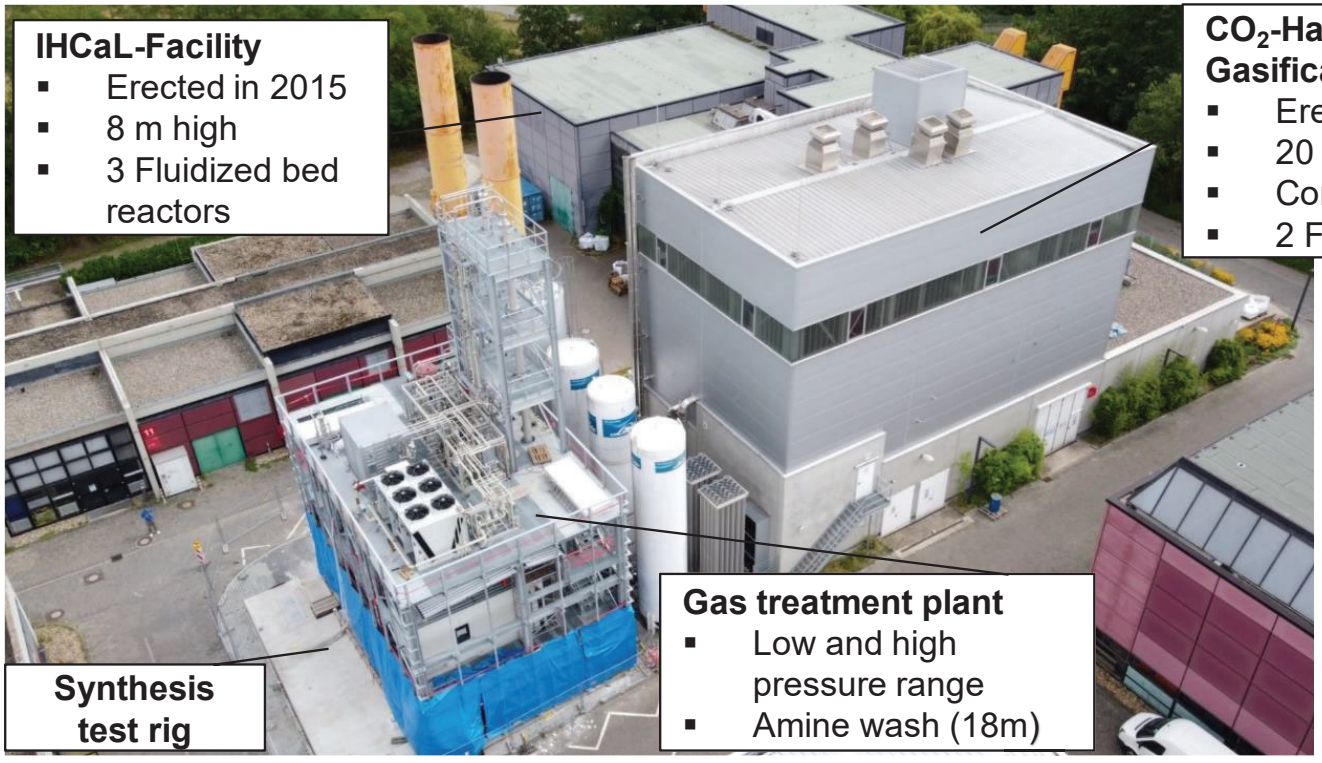
Accelerating CCS Technologies

ANICA

Thank you for your Attention

CO_2 Capture - Pilot Plants at TU Darmstadt



IHCaL-Facility
- Erected in 2015
- 8 m high
- 3 Fluidized bed reactors

CO_2-Hall – CaL/ Gasification Facility
- Erected in 2009
- 20 m high
- Combustion chamber
- 2 Fluidized bed reactors

Synthesis test rig

Gas treatment plant
- Low and high pressure range
- Amine wash (18m)

EST Homepage

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