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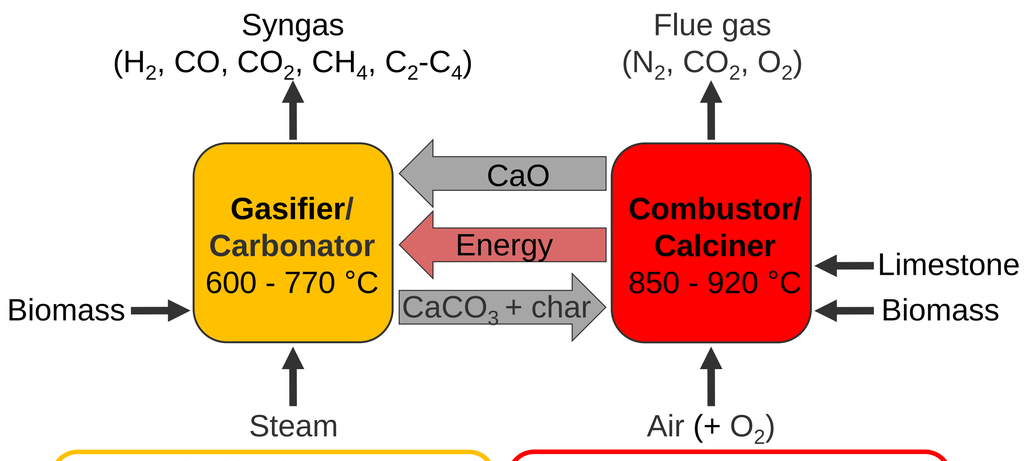
Experimental Investigation of the Sorption Enhanced Gasification of Biomass in a Dual Fluidized Bed Pilot Plant

EUBCE 2019
Lisbon, Portugal, 27th-30th May 2019

Introduction

- For reducing the anthropogenic climate change, greenhous gas emissions such as those caused by the transport sector need to be decreased significantly
- Optimized production of renewable transport fuels (e.g. DME) requires a H_2-rich product gas that is tailored for the respective downstream synthesis process
- Such a product gas can be produced by sorption enhanced gasification (SEG) of biomass, an indirect gasification process using a CaO-based CO_2-sorbent

Sorption enhanced gasification (SEG) process



Carbonation/ in-situ CO_2 capture
$CaO + CO_2 \rightleftharpoons CaCO_3$ exothermic
Water-gas-shift
$CO + H_2O \rightleftharpoons CO_2 + H_2$ exothermic

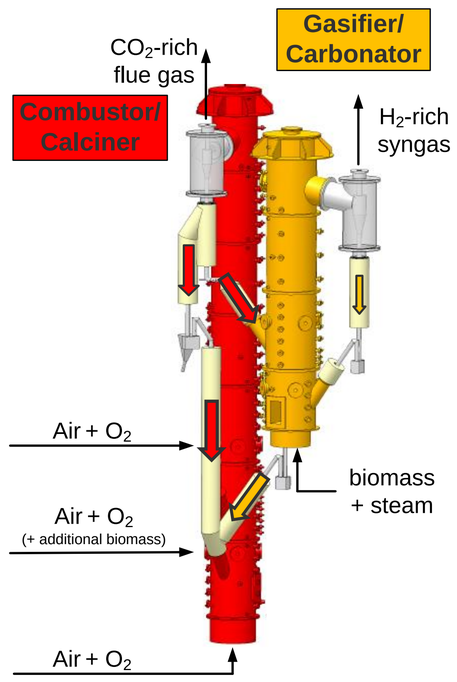
Calcination
$CaCO_3 \rightleftharpoons CaO + CO_2$ endothermic
Char combustion
$C + O_2 \rightleftharpoons CO_2$ exothermic

- CO_2 is absorbed in the gasifier to adjust the C/H content in the syngas
- Production of H_2-rich and N_2-free syngas with no need of pure oxygen
- Low tar conc. due to CaO bed material, despite low gasification temp.

200 kW_{th} dual fluidized bed facility

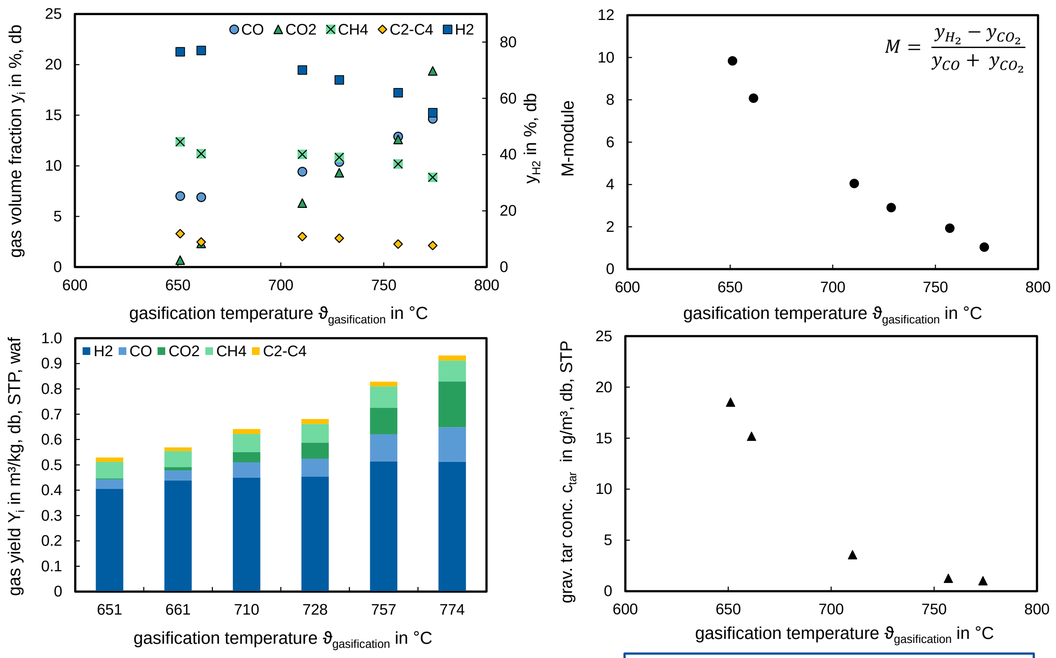
	Gasifier/ Carbonator	Combustor/ Calciner
Reactor height	6 m	10 m
Reactor diameter	0.33 m	0.21 m
Regime	BFB	CFB

- No external heating
- Gasification temperature controlled by solid looping rate that is adjusted by a screw conveyor
- Continuous measurement of standard gas components via ABB AO2020 gas analyzer: H_2, O_2, CO, CO_2, CH_4
- Measurement of lower hydrocarbons (C_2-C_4) via Varian CP-4900 Micro GC: C_2H_4, C_2H_6, C_3H_6, C_3H_8, C_4H_{10}
- Wet chemical tar measurement according to the tar protocol



Experimental results

Influence of gasification temperature on the syngas composition

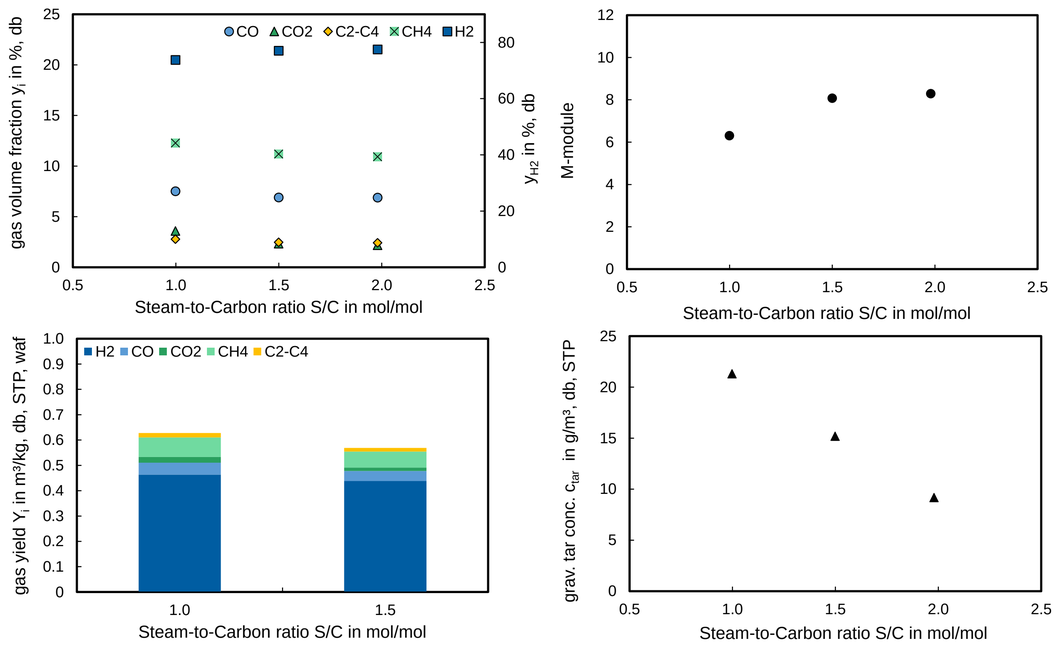


- Hydrogen concentrations of up to 77%
  → Process suitable for H_2 - production
- M-modules between 10 and 1
  → Syngas can be adjusted for several downstream synthesis processes

Significant influence of $\vartheta_{gasification}$

Operation conditions
- Fuel: wood pellets
- S/C ratio: 1.5 mol/mol
- $\vartheta_{gasification}$: 651 - 774 °C
- $\vartheta_{calcination}$: 914 ± 12 °C

Influence of the Steam-to-Carbon ratio on the syngas composition



- No significant influence of S/C ratio on standard gas composition and yield
- Tar concentration decreasing with increasing S/C ratio

Operation conditions
- Fuel: wood pellets
- S/C ratio: 1 - 2 mol/mol
- $\vartheta_{gasification}$: 662 ± 4 °C
- $\vartheta_{calcination}$: 921 ± 3 °C

db – dry basis, STP – standard temperature and pressure (0 °C, 101.3 kPa), waf – water and ash free

Conclusions

- Flexible syngas adjustment by variation of gasification temperature possible to be suitable for the respective downstream synthesis process
- Tar concentration can be decreased significantly by increasing the S/C ratio
- Further investigations with biogenic waste material will be conducted

Acknowledgement
The FLEDGED project has received funding from the European Union`s Horizon 2020 research and innovation programme under grant agreement No 727600.

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