Biomass gasification integrated into a coal oxy-boiler

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• Introduction
• Concept
• Performance of the oxy-CO$_2$-gasifier
• Utilization options
• Demonstration plant
Oxycombustion

- Method of CO$_2$ capture
- Coal boilers with air $\rightarrow$ O$_2$
- First demonstrations units under development
Biomass gasification

- Method of reducing CO$_2$ emissions
- Produced gas can be used in a variety of applications
- “Developed” technology: still not commercial for applications different from direct burning the gas
Biomass Gasification

Autothermal
- Aire
  - HV: low
  - N₂: high
  - H₂: low
- O₂/H₂O
  - HV: medium
  - N₂: none
  - H₂: high

Alothermal
- H₂O
  - PC: medium
  - N₂: none
  - H₂: high
- CO₂
  - PC: Medium
  - N₂: none
  - H₂: high

HV: high
N₂: none
H₂: high

O₂/CO₂
- HV: medium
- N₂: none
- H₂: low
Integration of a gasifier in an oxycombustion plant

- Replacing coal with biomass
- CO$_2$ capture + CO$_2$ reduction
- Production of other products (poligeneration)
Why in fluidized bed?
- Adequate for all scales (2 MW\textsubscript{th}-500 MW\textsubscript{th})
- Adaptation to change of fuel and properties

Why CO\textsubscript{2} instead of steam?
- CO\textsubscript{2} available. The aim is to sequestrate extra-CO\textsubscript{2}
- Though, H\textsubscript{2}O can be used
- High energy loss using steam: latent heat
- CO\textsubscript{2} cannot be separate as easy as steam
- How we will use the gas?
Performance of a oxy-CO$_2$ FBG

**O$_2$-steam**
Adjustment of
- O$_2$ / biomass ratio
- Steam / O$_2$ ratio

**O$_2$-CO$_2$**
Adjustment of
- O$_2$ / biomass ratio
- CO$_2$ / O$_2$ ratio

**Optimization:** adjustment the two ratios for:
- Complete fuel conversion (efficiency)
- Minimizing tar content in the gas (application)
- CO$_2$ content in the produced gas?
- Other?
Performance of a oxy-CO$_2$ FBG
Simulation

**Wood**
- 50% C w/w
- 1.3 kg O$_2$/kg dry wood for complete combustion

**Gasification Agent:**
- Kg O$_2$ / kg dry wood = 0.4 (ER≈0.3)
- Kg CO$_2$ / kg O$_2$ = 2 – 4

**Results:**
- CO$_2$ conversion is negative (50% CO$_2$ v/v in the dry gas)
- CO/H$_2$ (v/v)≈3
- LHV of dry gas= 7 MJ/Nm$^3$ (twice after CO2 separation)

**To be adjusted:**
- Temperature (ER and gas recirculation ratio)
- Composition of the recirculation stream (steam)
4. Utilization options

Utilization options

- **OXY BOILER**
- **CARBON CAPTURE AND SEQUESTRATION**
- **O2 PLANT**
- **BIOMASS**
- **COAL**
- **H2O**
- **CO2 Rich stream**
- **PRODUCED GAS**
- **GAS ENGINE**
- **CO2 SEPARATION**
- **SYNTHESIS 1**
- **SYNTHESIS 2**

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Green CO$_2$-sequestration capacity

1 kg$_{\text{dry wood}}$ → 0.8-1.5 kg CO$_2$ → 1.9 kg CO$_2$ sequestred

$\approx 2$ kg CO$_2$ sequestred/kg$_{\text{dry wood}}$

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4. Utilization options
Discussion of gas utilization

Co-firing

Advantages

- Easy gas cleaning
- High efficiency to electricity
- Coal substitution by biomass
- It is **better than direct firing** the biomass:
  - Ash from biomass are not mixed with coal ash
  - Biomass milling is not necessary (PC boilers)

But:

- May it affect the boiler? A function of biomass/coal
- Needs special burners? Could be act as “moderator”?
- No poligeneration: only power is produced
Advantages
• Independent of the boiler
• Acceptable power efficiency but lower than cofiring
• The flue gas from the engine gas directly to CO$_2$ sequestration

Disadvantages
• (Significant) gas cleaning is needed (tars)
Advantages

- The highest value of end-product
- Some bio-synthesis process requires CO\(_2\): no CO\(_2\) separation is necessary
- Poligeneration

Disadvantages

- Extensive gas cleaning and preparation is necessary
- CO\(_2\) needs to be separated for most synthesis processes
Biomass gasification integrated into coal oxy-boilers:

• is an attractive concept of CO₂ reduction + sequestration storage with poligeneration
• is related to oxycombustion (oxy-firing units are in development)
• economic evaluations of the utilization routes necessary