Dual Fluidised Bed for Catalytic Cleaning of Biomass gas

Aim of research

- Continuous gas cleaning by changing chemical structures of tars
- Gas reactions in a bench scale system of dual fluidised beds, catalytic bed material with regeneration
  - Raw gas from Chalmers biomass gasifier
  - Synthetic gases and tars
- Optimisation towards SNG-production
  - Prevent the breaking down of methane
  - Controlling H2/CO-fraction
New gas cleaning methods, Why!

- Tars; Condensable hydrocarbons (single ring to 5-ring aromatic compounds)
- Fouling of downstream equipment
- Conventional gas conditioning: removal of tars by condensation $\rightarrow$ Thermodynamic penalty
- Deactivation of catalysts, carbon fouling

Reactor system

$$C_nH_m + n MeO \rightarrow n CO + \frac{m}{2} H_2 + n Me$$

$$n Me + \frac{n}{2} O_2 \rightarrow n MeO$$
Solid-Phase Adsorption (SPA)

Addition of internal standard

Product gas → SPA → Elutropic solvent desorption → GC-FID

Aromatics

Phenolics
Reaction mechanisms

\[ C_n H_m + \frac{n}{2} O_2 \rightarrow nCO + \frac{m}{2} H_2 \] Partial Oxidation

\[ C_n H_m + x \ H_2 O \rightarrow \left( n + \frac{x}{2} \right) H_2 + n \ \text{CO} \] Steam reforming

\[ C_n H_m \rightarrow n \ C + \left( \frac{m}{2} \right) H_2 \] Carbon formation

\[ C_n H_m + \left( n + \frac{m}{4} \right) O_2 \rightarrow n \ CO_2 + \left( \frac{m}{2} \right) H_2 O \] Combustion

How to control oxygen transfer

Fluid dynamics in the system
• Solid circulation rate
  - Too much oxygen → no product gas
  - Too little oxygen → carbon fouling of catalysts

Solution 1: Controlled gas environment in air reactor

Solution 2: Mix inert particles with the catalysts

Separation between bed materials?
Inert particles and catalysts  
(Ilumenite and Sand)

Cold System identical in size

- Fluidization Media
  - Air
  - Helium (scaling laws by Glicksman)

- Solid Circulation Rate
  - Particle size of bed material, round sand
    - 90 < dp < 250 μm
  - Mixing of bed materials, ilumenite and sand

- Pressure Mapping
  - Optimizing pressure sensor setup
  - Controlling solid rate circulation from pressure signal
Experiments in hot system

Operation
- 56 hours of bed circulation, mixed bed material
- 36 hours of raw gas operation

Sand and oxygen active components
- Ilumenite
- Manganese oxide
- Nickel oxide

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Fredrik Lind Division of Energy Conversion
Conclusions

First experiments show:
- Tar composition is effected by the reformer system
- Regeneration of the catalysts is working
- Gas composition can be controlled
  Ilumenite $\rightarrow$ $\text{H}_2/\text{CO} \approx 3$