Packed Bed Methane Sorption with Activated Carbon - experiments and modeling

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April 2014
ECN-M--14-071

EDGaR
Energy Delta Gas Research

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Introduction

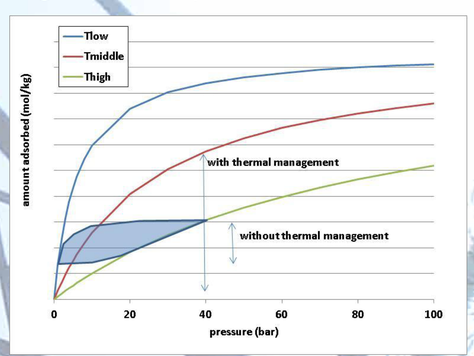
Decentralised gas storage will become increasingly important in the future (bio)gas infrastructure to match supply and demand. Various technologies are available to store gas, such as LNG (V/V[1] ~600 at -160° C, CNG V/V ~ 240 at 200 bar) and ANG (up to V/V ~200 at ~35bar). In ANG, natural gas is stored by adsorbing it on activated carbon. In this way, methane can be stored in a compact way at relatively low pressures.

The amount of methane that can be stored depends strongly on the type of activated carbon (specific surface area, density, pore size distribution), but also the temperature is an important factor.

[1]V/V is the normal volume of the gas under 1 bar divided by the effective volume of the adsorption bed.

Thermal effect in sorption storage

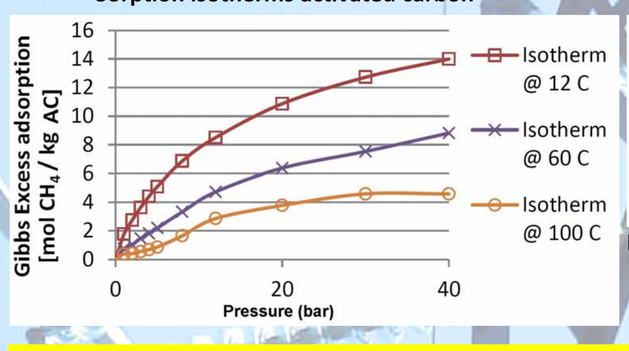
- On loading of the carbon with methane, sorption heat is released, raising the temperature of the storage. This temperature rise decreases the methane uptake.
- Similarly, on extracting the methane from the carbon, sorption heat is extracted, freezing the storage. This reduces the discharging of the storage.

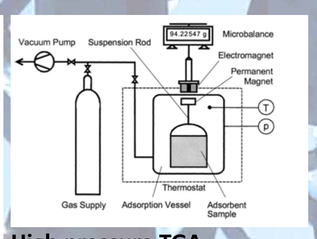


Sorption measurements effect of temperature

High-pressure Sorption experiments were carried out to determine the CH_4 loading as a function of pressure for different activated carbons and different temperatures.

Sorption isotherms activated carbon





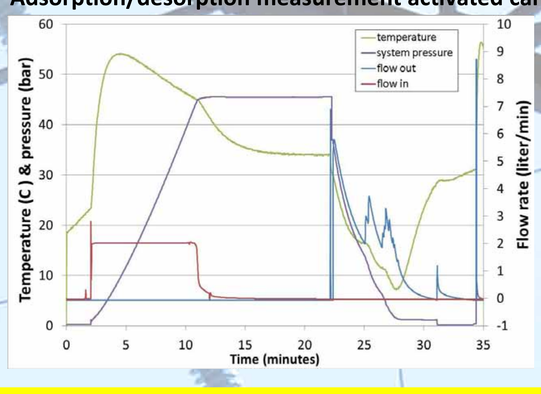
High pressure TGA

Experiments of CH_4 adsorption in packed bed

An experimental setup was built to determine CH_4 adsorption / desorption performance on activated carbon.

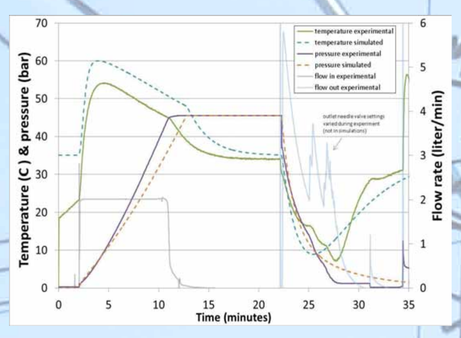
tube-in-tube reactor
(inner tube filled with the activated carbon, oil coolant flow between inner and outer tube)

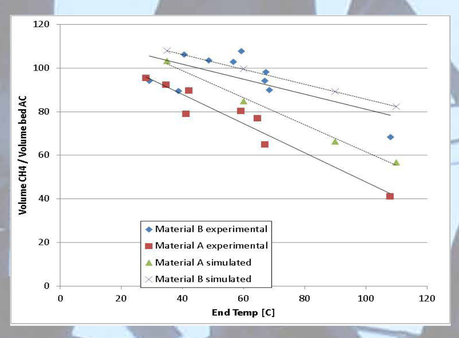
Adsorption/desorption measurement activated carbon



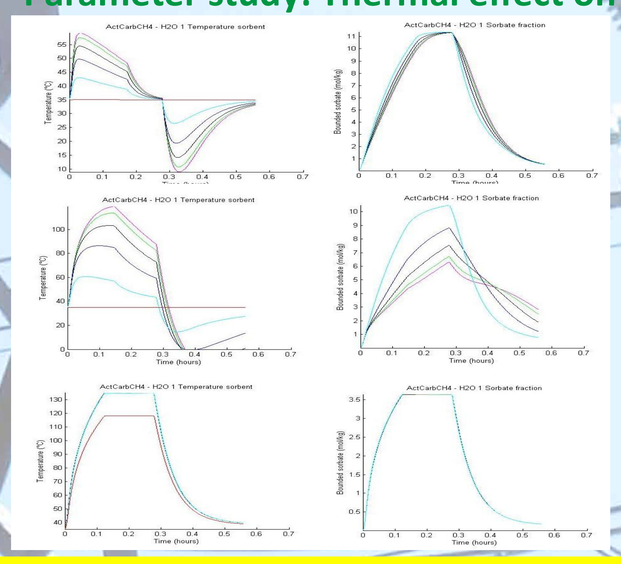
Simulations of CH_4 adsorption in packed bed

- A packed bed model was built of the experimental setup.
- Assumptions: high bed permeability (homogeneous pressure).





Parameter study: Thermal effect on V/V



Conductivity and bed sizing strongly influence the V/V

- Top: experimental reactor (reference): V/V=103
- Middle: reference with low conductivity: V/V= 79
- Bottom: reference without heat losses from bed: V/V = 47

Conclusions

- Strong differences exist between different types of activated carbon, in which packed bed density is particularly important. Therefore, monolith development is important to obtain a high V/V.
- Thermal effects can reduce the performance of a packed bed with activated carbon to about 35% of its theoretical sorption capacity. Therefore, thermal management is important to obtain a good storage performance.

Acknowledgements

This research was part of the Flexistore project, financed by the EDGaR programme. Project consortium: Hanze university Groningen, RUG, ECN, Gasunie (KEMA) and Enexis, Stedin and Liander (KIWA)

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