Single Pellet DP-PSA Experiments for the Characterisation of Heat and Mass Transfer Parameters

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Overview of DP-PSA system

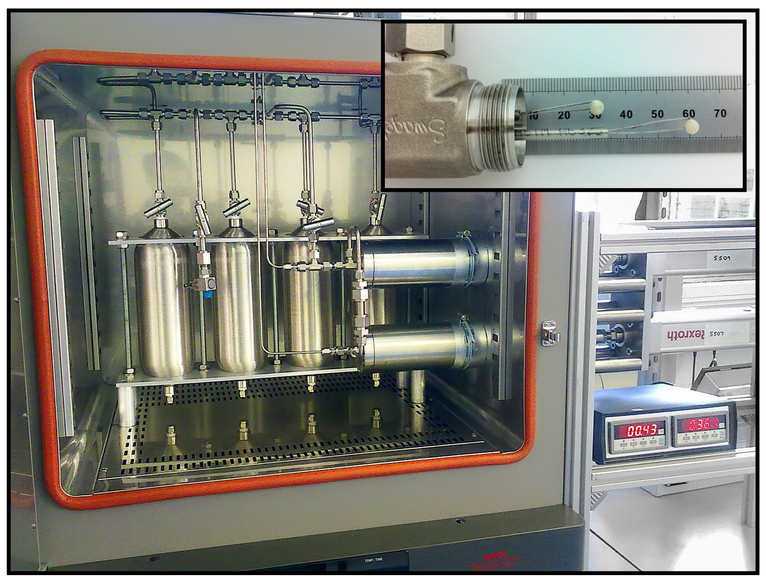


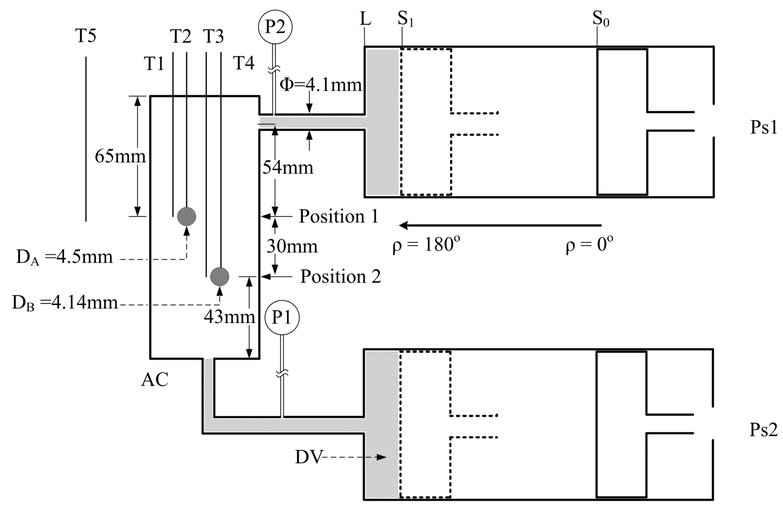
Figure 1. Dual-Piston Pressure Swing Adsorption (DP-PSA) system. The inset shows the position of the 4 thermocouples inside the column.

Aim

Extract heat and mass transfer information from temperature data of the single pellet DP-PSA system

Experimental system

- Closed system with two independently controlled pistons:
  - Cycle times from seconds to minutes
  - Different pressure ratios and profiles
- Measurements:
  - Absolute pressure and pressure drop
  - Two pairs of thermocouples along the column length
  - In each pair one in the gas phase and one inside a 13X pellet



Tx – Thermocouple x
AC – Adsorbing Column
S_0 – Start position
S_1 – End position
Ps1 – Piston 1
Ps2 – Piston 2
DV – Dead Volume
L – Piston length
P1 – Pressure drop column
P2 – Pressure top of the column
D_A – Diameter of solid A
D_B – Diameter of solid B

Figure 2. Schematic showing the DP-PSA system

Comparison of the experimental data with simulations

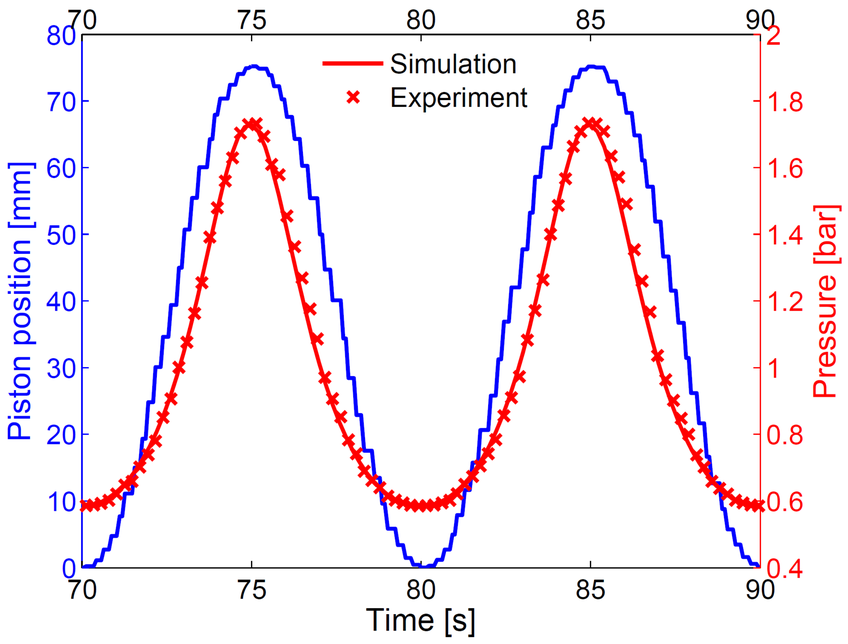


Figure 3. Comparison of the simulated and measured pressure for a helium run. Also shown is the position of the two pistons.

Pressure profile

- Pressure profile depends mainly on piston position and thus system volume
- Minor influence of fluid temperature
- Experimental pressure profile agrees with simulated pressure profile

Temperature profile

- For non-adsorbing gases the fluid temperature depends on the compression and wall heat transfer
- Measured temperature profile lags behind the simulated temperature
- Simulated and measured temperature profiles agree if the thermocouple (TC) response is included

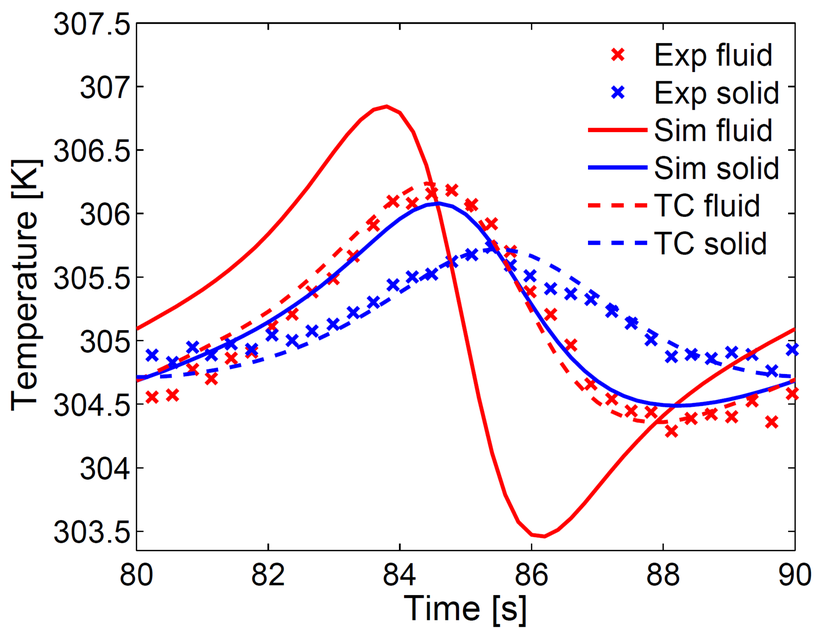


Figure 4. Comparison of the measured and simulated temperature profile for a helium run

Heat transfer between the fluid and solid phase

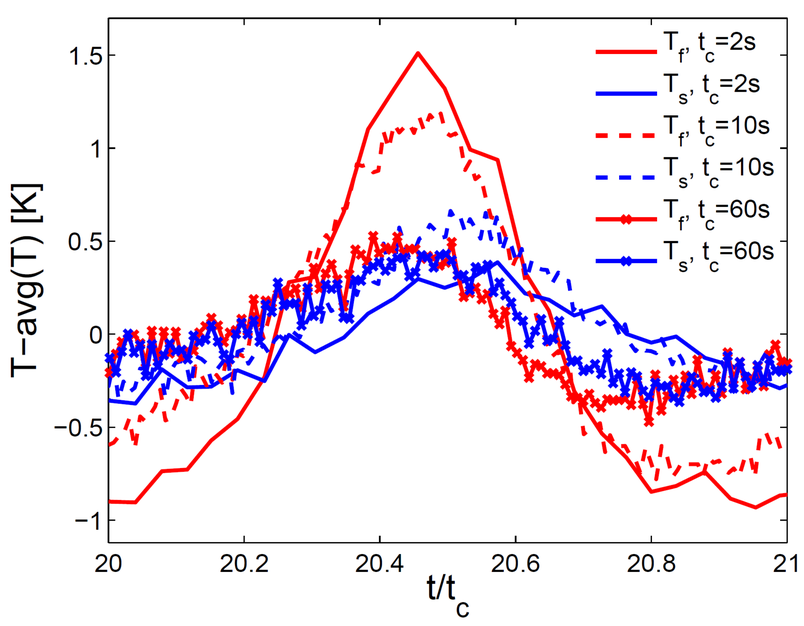


Figure 5. Comparison of the experimental fluid phase temperature (T_f) and solid phase temperature (T_s) profile for helium runs at different cycle times (t_c)

Temperature profile

- The solid lags behind the fluid temperature due to gas/solid heat transfer
- The temperature profile for a fast cycle (t_c=2s) shows that the thermocouples are responsive enough to capture the temperature swing in the fluid phase
- The CO_2 runs in Figure 6 show the effect of mass transfer and heat of adsorption on the solid phase temperature

Conclusion

- Good agreement between the simulated and experimental profiles
- Heat transfer coefficients can be gained from helium runs and mass transfer coefficients from CO_2 runs

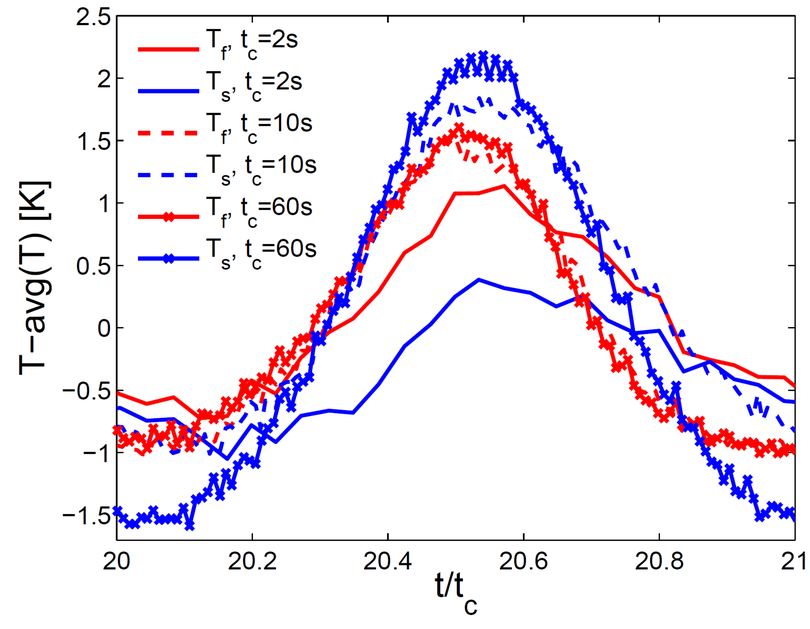


Figure 6. Comparison of the experimental fluid phase temperature (T_f) and solid phase temperature (T_s) profile for CO_2 runs at different cycle times (t_c)

Acknowledgements

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References

1. Friedrich, Ferrari, Brandani: Efficient Simulation and Acceleration of Convergence for a Dual Piston Pressure Swing Adsorption System, Industrial & Engineering Chemistry Research, 2013.
2. Dang, Friedrich, Brandani: Characterisation of an automated Dual Piston Pressure Swing Adsorption (DP-PSA) system, Energy Procedia, in press.