



Hydrogen separation using membranes

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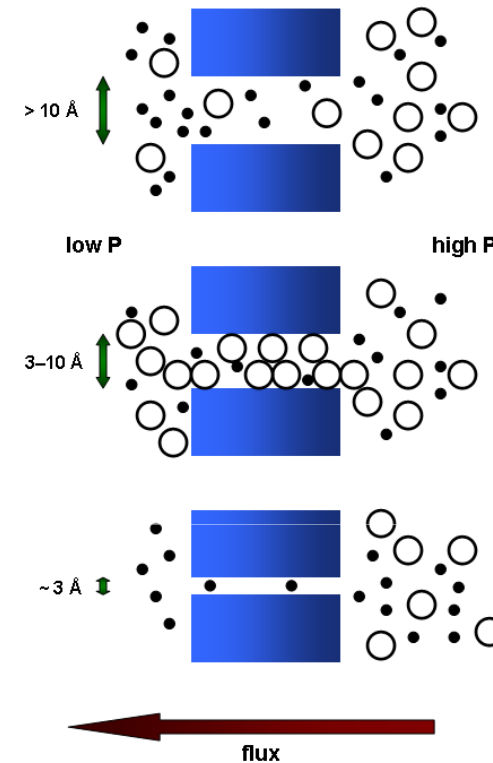
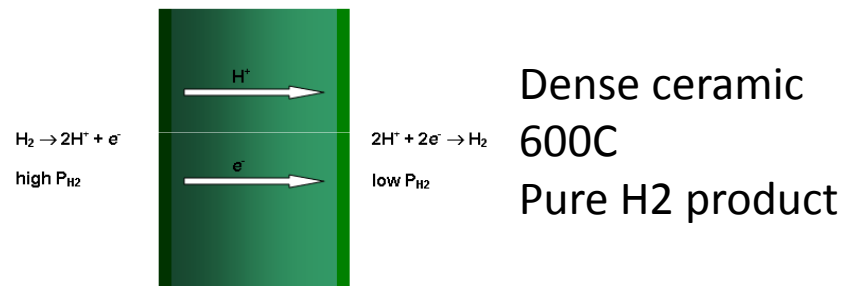
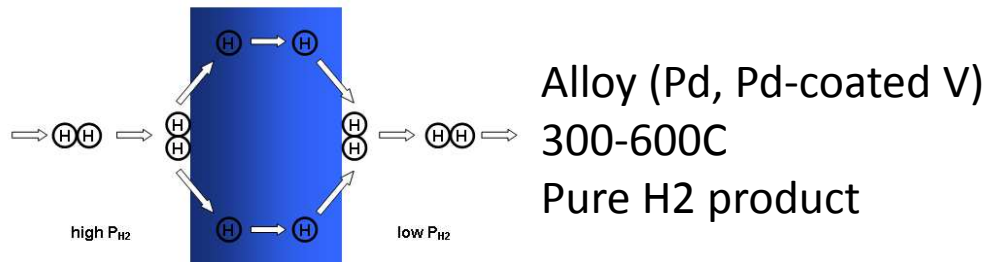
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Scope

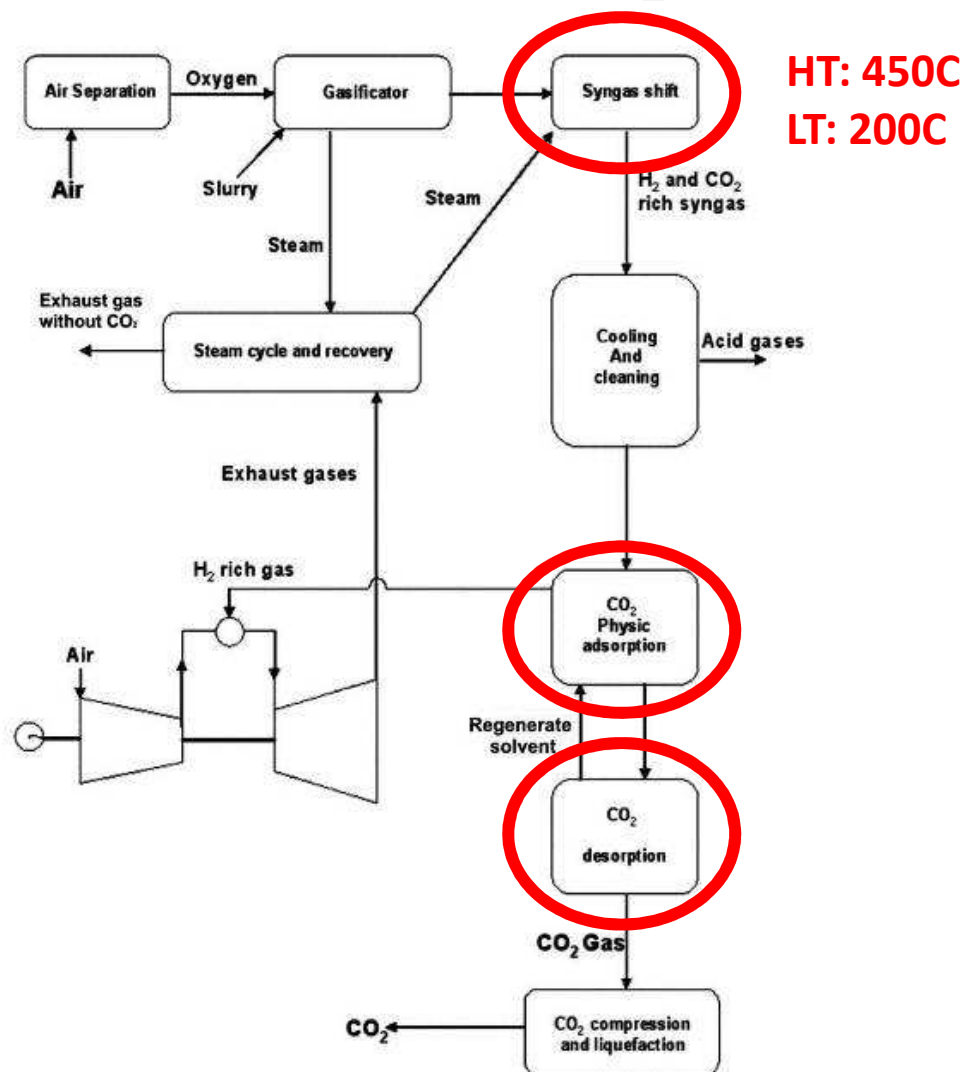
- High-temperature H₂-selective membranes
- The role of membranes in pre-CC
- Catalytic membrane reactors
- CMR performance characteristics
- CMR optimisation

High-temperature H₂-selective membranes



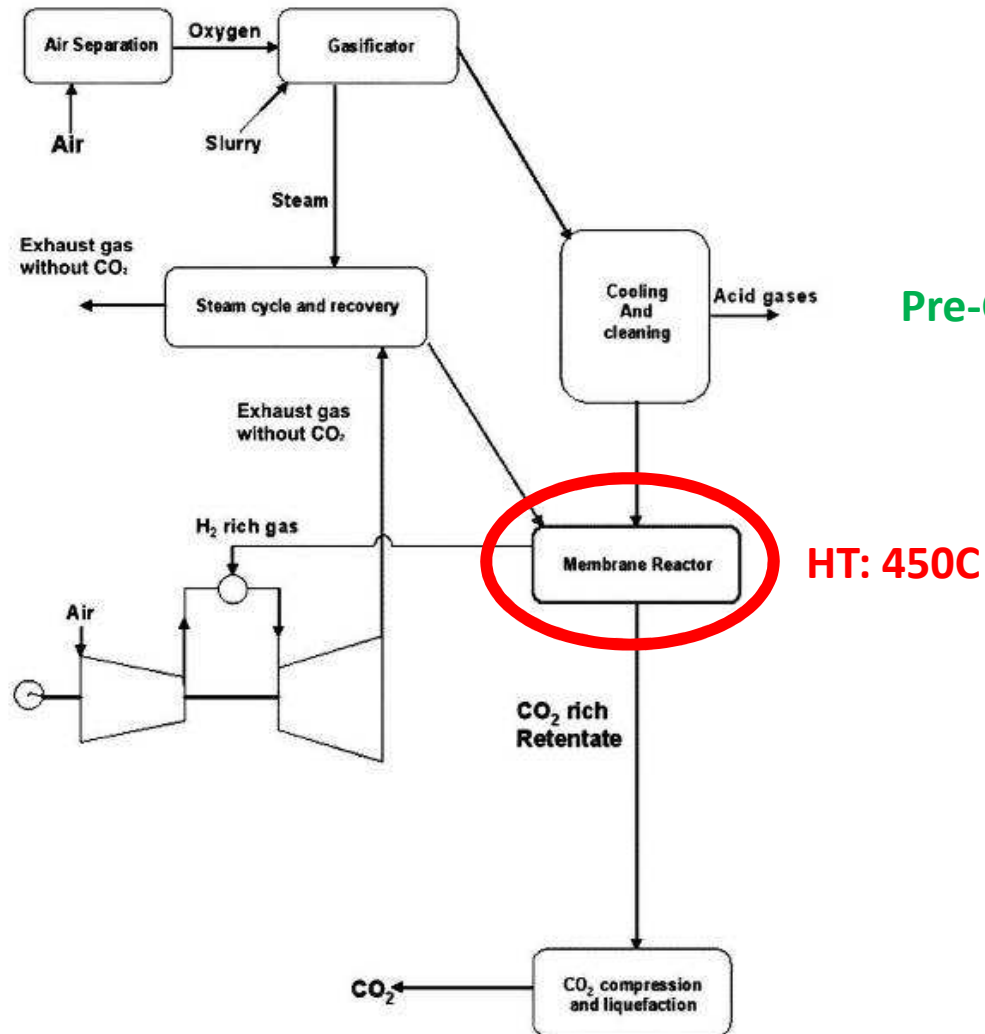
Microporous (eg, SiO₂)
< 300C
< 100% H₂ (depending on pore size)

Pre-combustion CO₂ capture (conventional)



Amelio et al, Integrated gasification gas combined cycle plant with membrane reactors: Technological and economical analysis. Energy Conversion and Management 2007;48(10):2680-2693.

Pre-combustion CO₂ capture (membrane reactor)

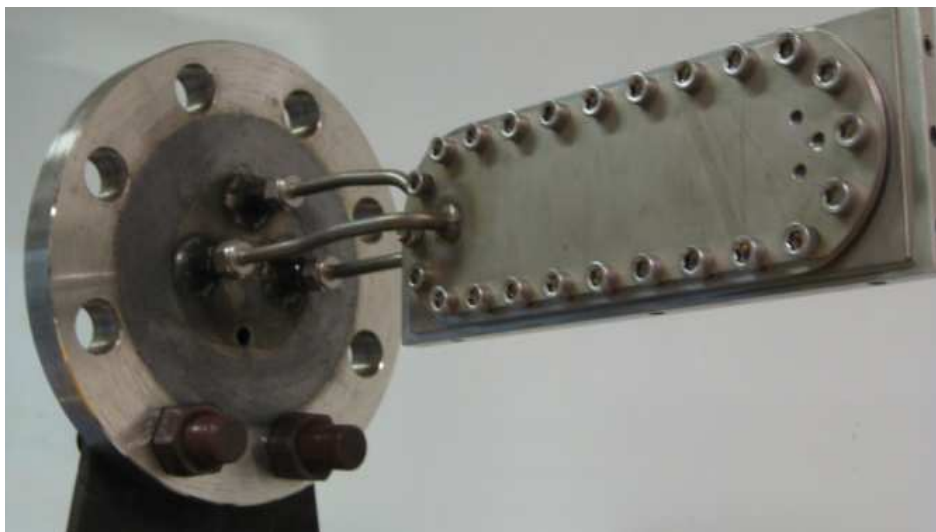
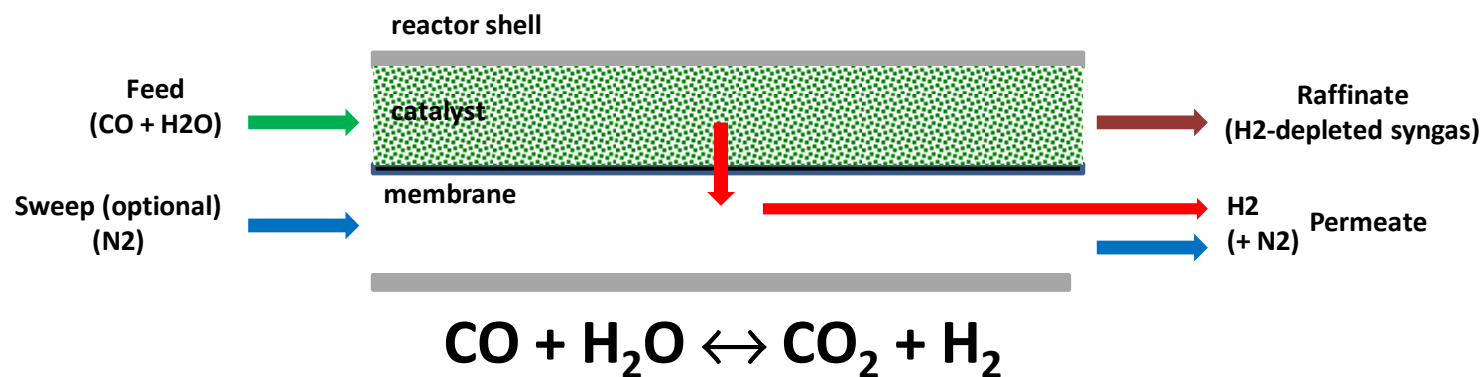


Pre-CMR desulfurisation

HT: 450C

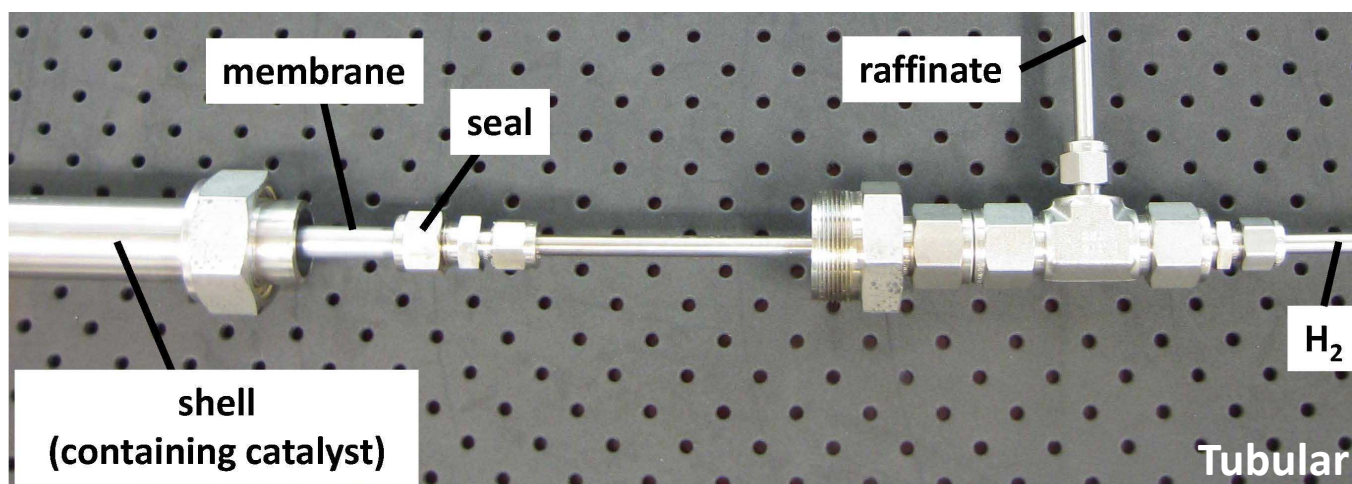
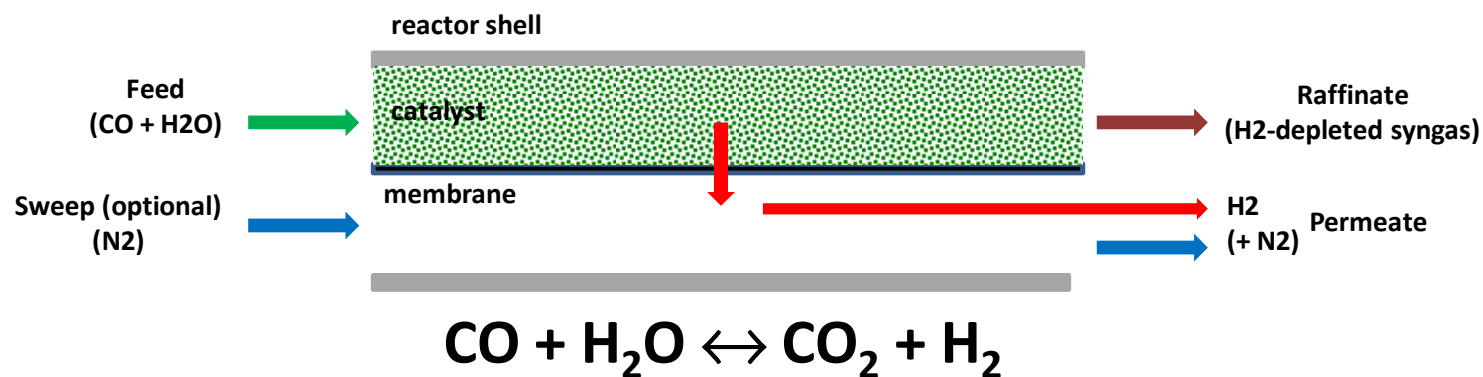
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The catalytic membrane reactor

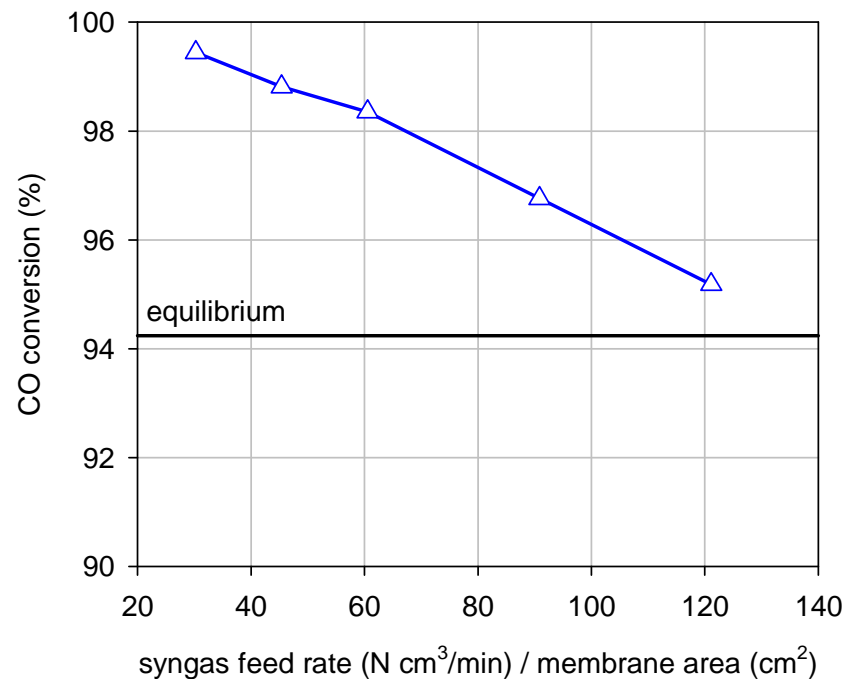


Planar

The catalytic membrane reactor



CMR performance characteristics



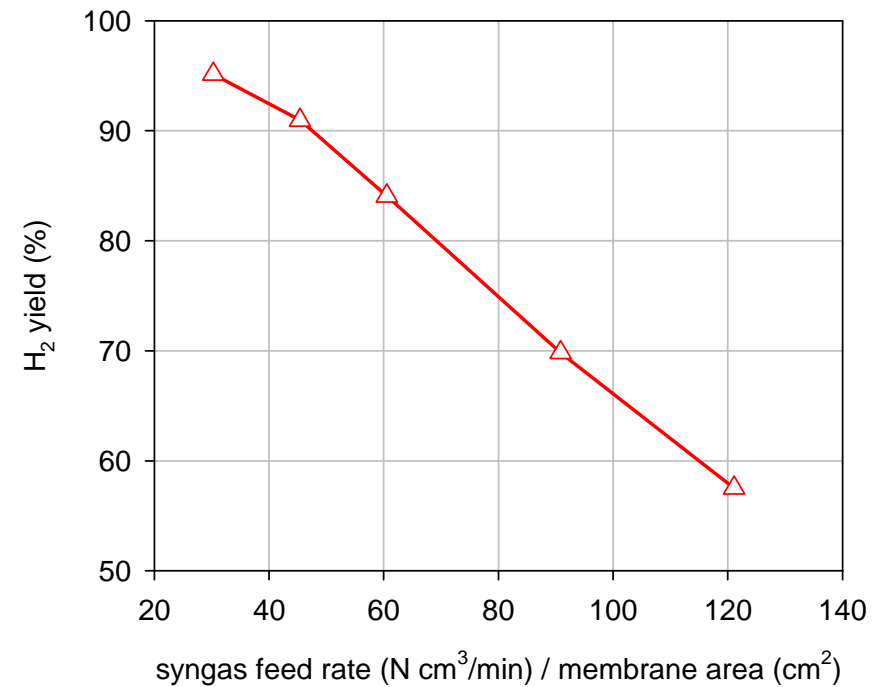
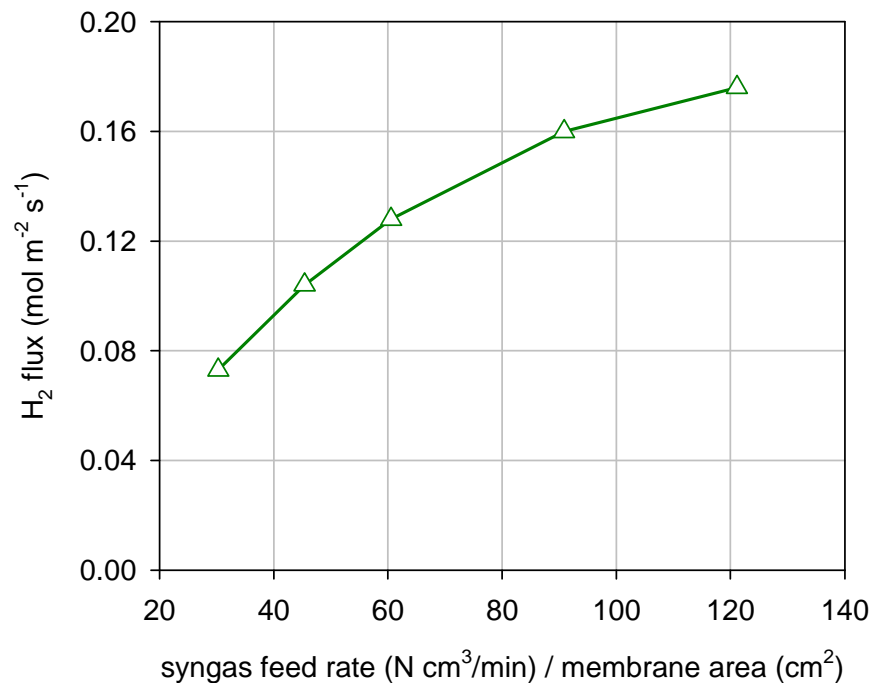
Removing H₂ from reactor promotes forward WGS reaction

Creates artificially-high equilibrium

Eliminates requirement for low-temperature WGS reactor

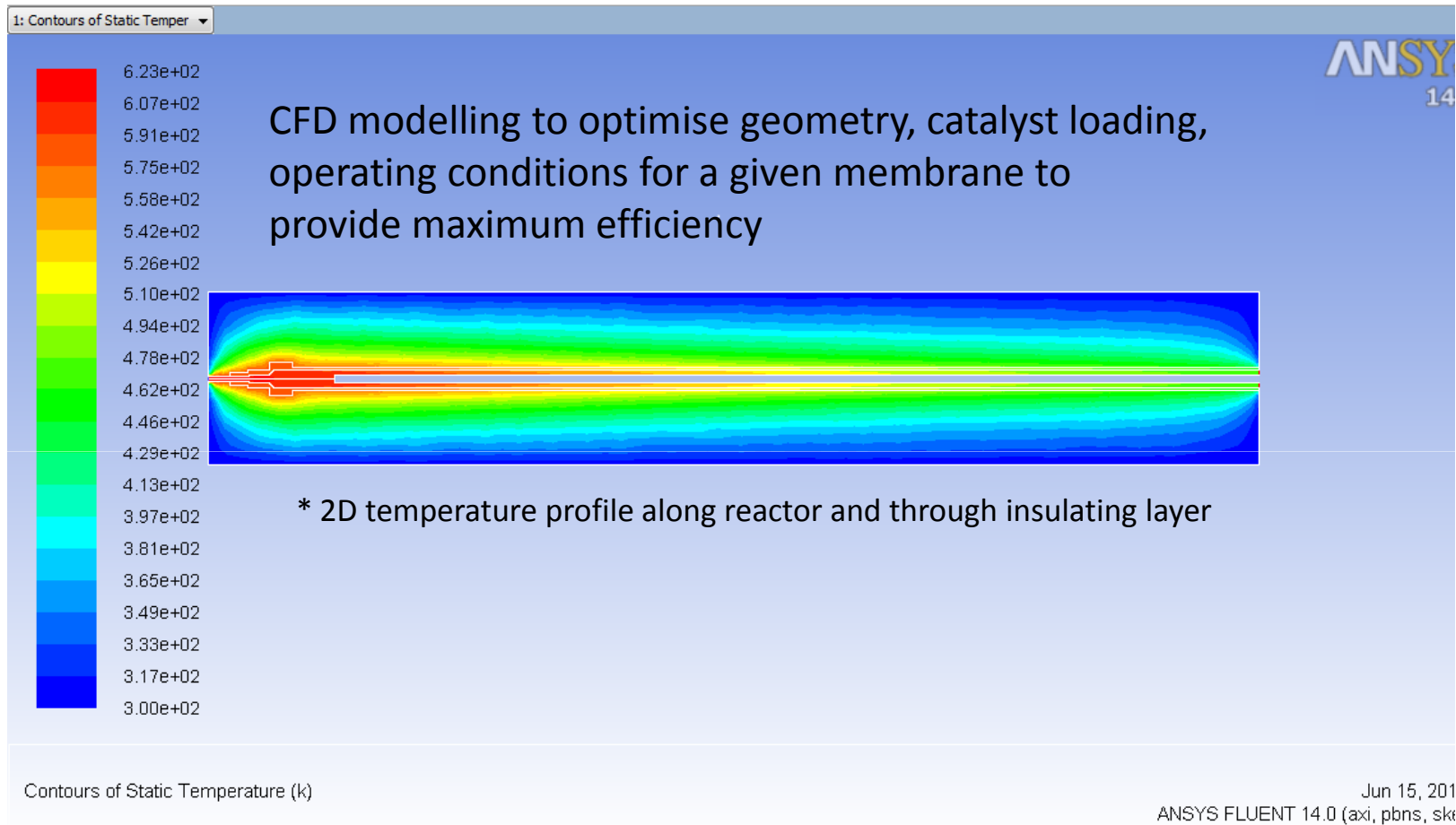
400C, 20 bar, 3:1 H₂O:C

CMR performance characteristics

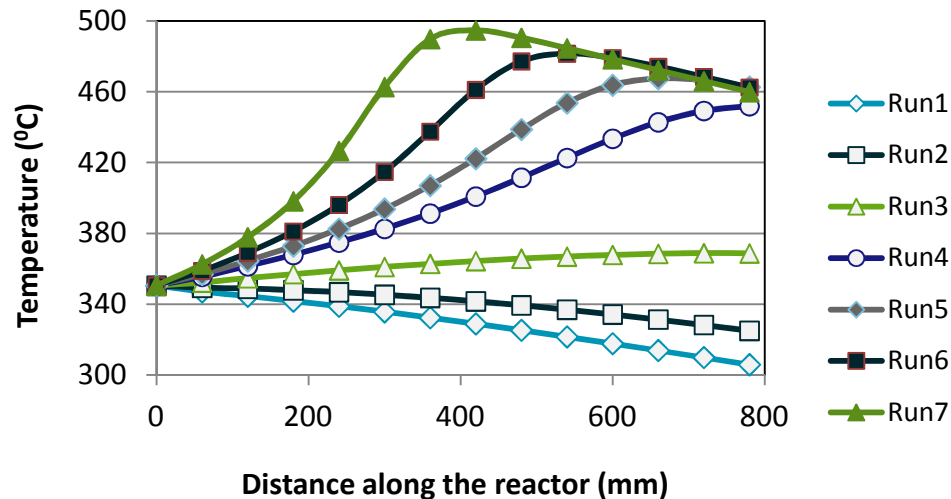


400C, 20 bar, 3:1 H₂O:C

Modelling heat flow and reaction rate

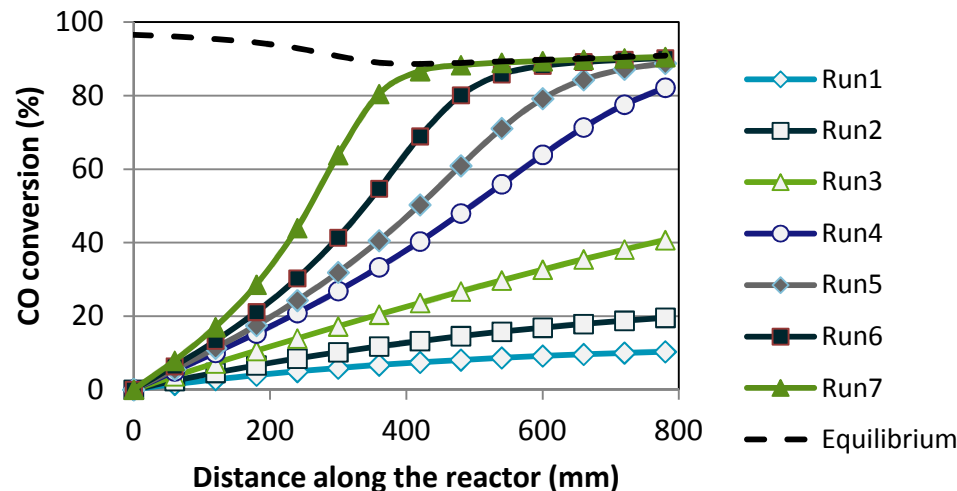


Modelling heat flow and reaction rate



Temperature varies along reactor length due to i) exothermic WGS reaction and ii) radiative and conductive heat losses

Membranes operate in fairly narrow temperature ranges (350-450°C for V-based alloy membranes)



Catalyst loading and feed flow rates must be tailored to minimise temperature gradient along reactor length

Summary

- Membranes: alloy membranes are infinitely selective to H₂
 - Can be used as a stand-alone H₂/CO₂ separator to produce pure H₂, or in a water-gas-shift membrane reactor
- Materials issues: the membrane is the key component
 - Must provide high H₂ flux, low cost, H₂S tolerance, tolerance to thermal cycling
- Catalytic Membrane Reactor: offers process intensification by combining several shift and separation stages in a single reactor
 - CO₂ captured pre-combustion at high pressure; chemical energy in syngas shifted from CO to H₂ for use in turbine, fuel cell, chemical synthesis, etc.

Acknowledgements

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