Shell Global Solutions

Norcap Seminiar
October 14-15, 2003

Radical Ideas,
Post Combustion Working Group CCP

Mariette Knaap, Shell Global Solutions, Rijswijk, the Netherlands

presented by Tom Mikus, Shell Global Solutions, Houston, USA

Radical Ideas

CO2 Capture from Flue Gas

- CO2 Capture from Flue Gas
  - Currently, 2 major commercial processes based on amines
    - Mitsubishi Heavy Industries (KS solvents)
    - Fluor Daniel (Econ-Amine solvents)
- Difficulties:
  - Presence of oxygen in flue gas: corrosion issues
  - Flue gas is at atmospheric pressure→
    - **Extremely** low driving force for CO2/ flue gas seperation
- Result:
  - High cost of CO2 capture from flue gas

Radical Ideas

CO2 Capture from Flue Gas: Advantages

- Low amount of parasitic CO2 (10-15% or lower)
- End-of-pipe solution
  - Can be applied to existing powerplants and systems
- No need for new gas-turbine developments etc.

Radical Ideas

Starting Point

- Middle 2003
  - Clear: Major Breakthroughs in Post Combustion Technology: Difficult
- Need for Radical New Ideas
  - 2 Literature Studies performed and evaluated
  - Over 1000 references reviewed
- 2 Themes identified
  - Flue gas recycle to gas turbine
  - Vacuum swing adsorption

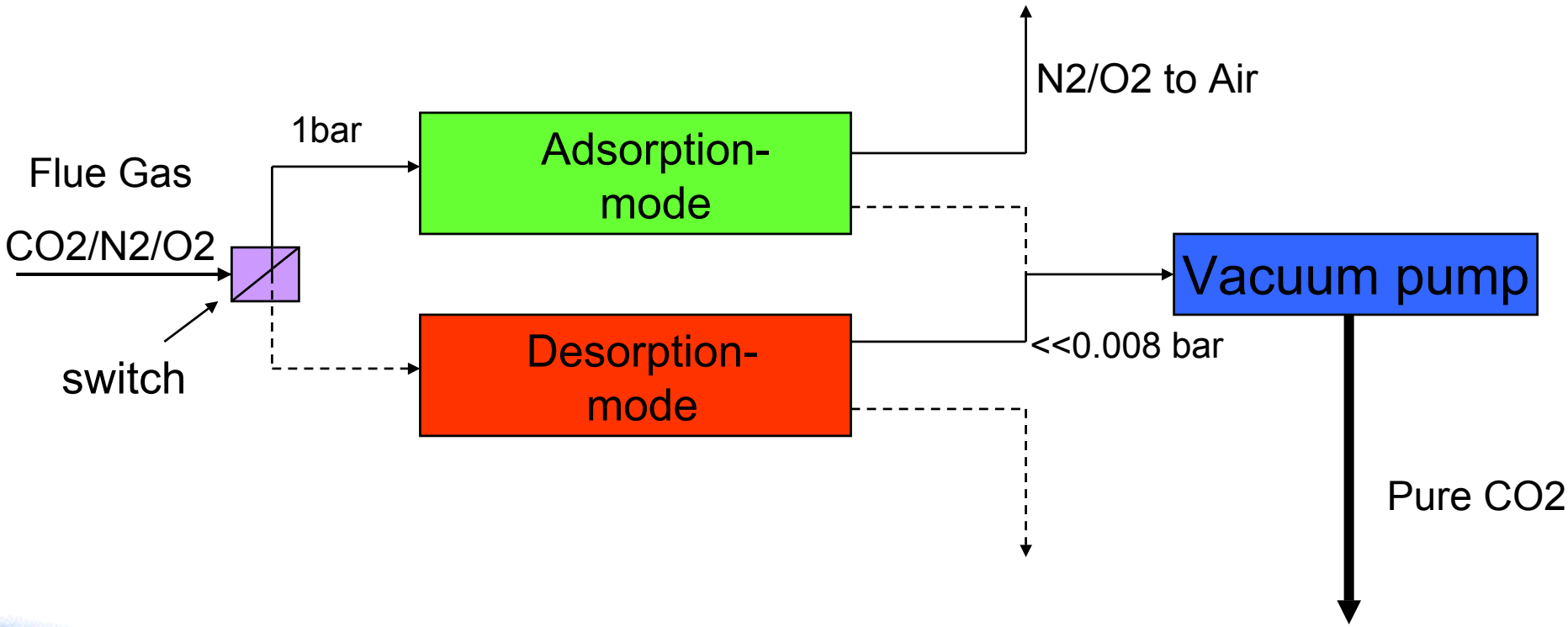
Radical Ideas

Flue gas recycle

- Flue gas recycle
  - Boosts CO2 from 4% to 8% in gas turbine flue gas
    - Proposed in IEA report PH3/14
    - Potentially cost reduction when applied to KS-1 solvent, based on Mitsubishi Heavy Industry quotes
  - Integrated into the CCP-Nexant Study:
    - Evaluated for MEA system as by Fluor Daniel

Radical Ideas

Vacuum Swing Adsorption



Radical Ideas

Vacuum Swing Adsorption

- Several vessels alternating in adsorption/desorption mode
- Adsorption: CO2 adsorbed on a sorbent
  - P(CO2) = 0.04 –0.08 bar at inlet vessel
  - P(CO2) = 0.004-0.008 bar at outlet vessel
- Desorption: CO2 desorbed under Vacuum,
  - Very low vacuum pressure needed:
    - Sufficient desorption driving force needed, p(vac)<<0.008 bar
    - Pressure drop over sorbent in vessel
    - Desorption energy required

Radical Ideas

Feasibility VSA

- Advantage:
  - No thermal energy needed, only mechanical energy
  - No oxygen problems
- Disadvantage:
  - Huge vacuum pumps needed:
    - high capital and electricity costs

Radical Ideas

Feasibility VSA II

- Should we even consider a VSA system?
  - Vendors contacted: UOP, Engelhard

    →yes, it may work

  → Universities(Twente, NL), Institutes (ARI) consulted

    →Yes it may work

Radical Ideas

Trends in the R&D world-wide

- New sorbents for CO2 capture from flue gas are being developed all the time, evidenced by:
  - Internal Post-Combustion CCP-work
  - R&D groups in Japan, USA, China, Europe
  - Literature searches, IEA conferences, etc.

Radical Ideas

Cost effective VSA system

- Assessment by Post Combustion Team
- Regenerative systems:
  - Cost are picked up at the desorption side
  - Most research focusses on adsorption side
  - Assessment of newly developed sorbents needed
    - Investigate: What is an optimal sorbent?
    - What are and what determines the cost of an effective system?

Radical Ideas

What is an optimal sorbent?

- What determines an optimal sorbent?
- Trade-offs
  - Adsorption:
    - High capacity, fast adsorption→ high affinity for sorbent
  - Desorption:
    - Low desorption energy, fast desorption→ low affinity for sorbent
  - Other issues:
    - Low pressure-drop for very large beds
    - high purity of CO2 product > 95%, while CO2 is on the adsorption side

Radical Ideas

Future Projects

- Model and assess a vacuum swing, adsorption-desorption system
  - Find properties of an optimal sorbent
  - Assess if cost-effective system can be found
- Resulting
  - Gives tool to assess newly developed sorbents
  - Sets direction for research groups in sorbents development
    - By-result: knowledge on vacuum regeneration can be applied in
      - Membrane systems
      - Transport assisted membrane systems

Radical Ideas

Conclusions

- Post Combustion Technology:
  - Ease of application: End-of-pipe
  - Difficult to find break-throughs
- Vacuum Swing Adsorption for CO2 capture from flue gas
  - Technically feasible
  - Has potential for cost reduction
- Study for optimal sorbent properties and simple modelling of the system needed to
  - Assess potential for cost reduction
  - Assess potential for break-through technology in CO2 capture
  - Set directions for current & future R&D in adsorption at universities, institutes etc.