ÚJV Řež, a. s.

Utilization of coal ash for CO_2 capture

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Outline

- COALBYPRO – possibilities of coal ash utilization for CO2 capture
- Low-temperature adsorption
- High-temperature adsorption
- UJV activities – CCS

COALBYPRO – possibilities of coal ash utilization for CO2 capture

1) Low-temperature adsorption

- Coal ash - CO_2 stored together with ash
- Zeolites (manufactured from ash) – adsorption/desorption cycles

2) High-temperature adsorption

- Ash as a sorbent in Calcium loop (utilization of Residual CaO/CaCO3)

Low-temperature adsorption

- Low-temperature adsorption = physical adsorption
- Weak bond based on physical forces (Van der Walls force etc.) – small adsorption heat (equivalent to condensation heat)
- Not specific
- Pore structure is needed – surface area, pore size
- Adsorption tepmerature usually under 50 °C
- Desorption temperature 150 – 250 °C

Low-temperature adsorption

1) Coal ash as adsorbent

- Expected very limited CO_2 capture (based on ash content and CO_2 produced)
- Expected very low adsorption capacity
- Adsorption only (no desorption)
- Elimination of desorption step – very low energy penalty/cost

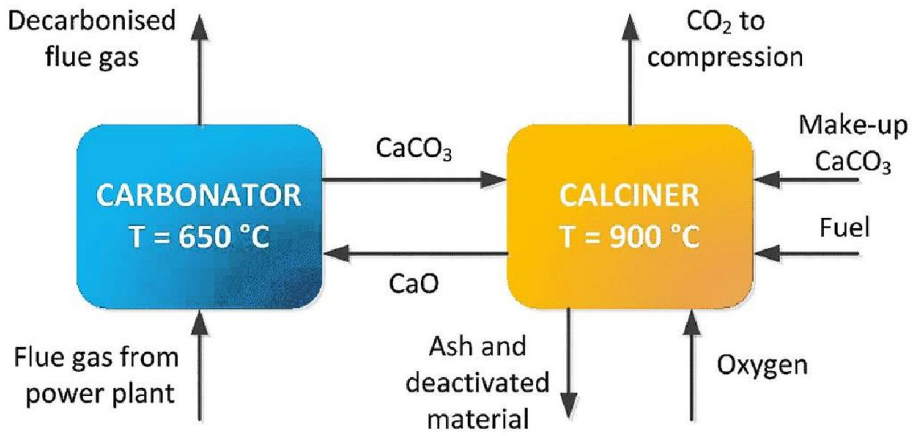
Low-temperature adsorption

2) Coal ash–derived zeolites

- Zeolite manufacture – complex process (sorbent must be re-used to be viable)
- Zeolites CO2 capacity range: 60 – 200 mg/g
- Possibility of doping by other elements to increase CO2 capacity over 200 mg/g
- Possible economical optimization of zeolite manufacture for each specific coal ash (not included in COALBYPRO)
- Free sorbent material

High-temperature adsorption

- High-temperature adsorption = chemical adsorption
- Strong chemical bond, CaO/CaCO3 dH = 178 kJ/mol
- Specific (can be competitive)
- Ads. tepm. 650 °C
- Des. tem. 900 - 950 °C



Carbonator: $CaO_{(s)} + CO_{2(g)} \rightarrow CaCO_{3(s)} + Heat$ *(exothermic reaction)*

Calciner: $CaCO_{3(s)} + Heat \rightarrow CaO_{(s)} + CO_{2(g)}$ *(endothermic reaction)*

Source: http://oenergetice.cz/rychle-zpravy/karbonatova-smycka-mozne-reseni-problemu-co2/

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High-temperature adsorption

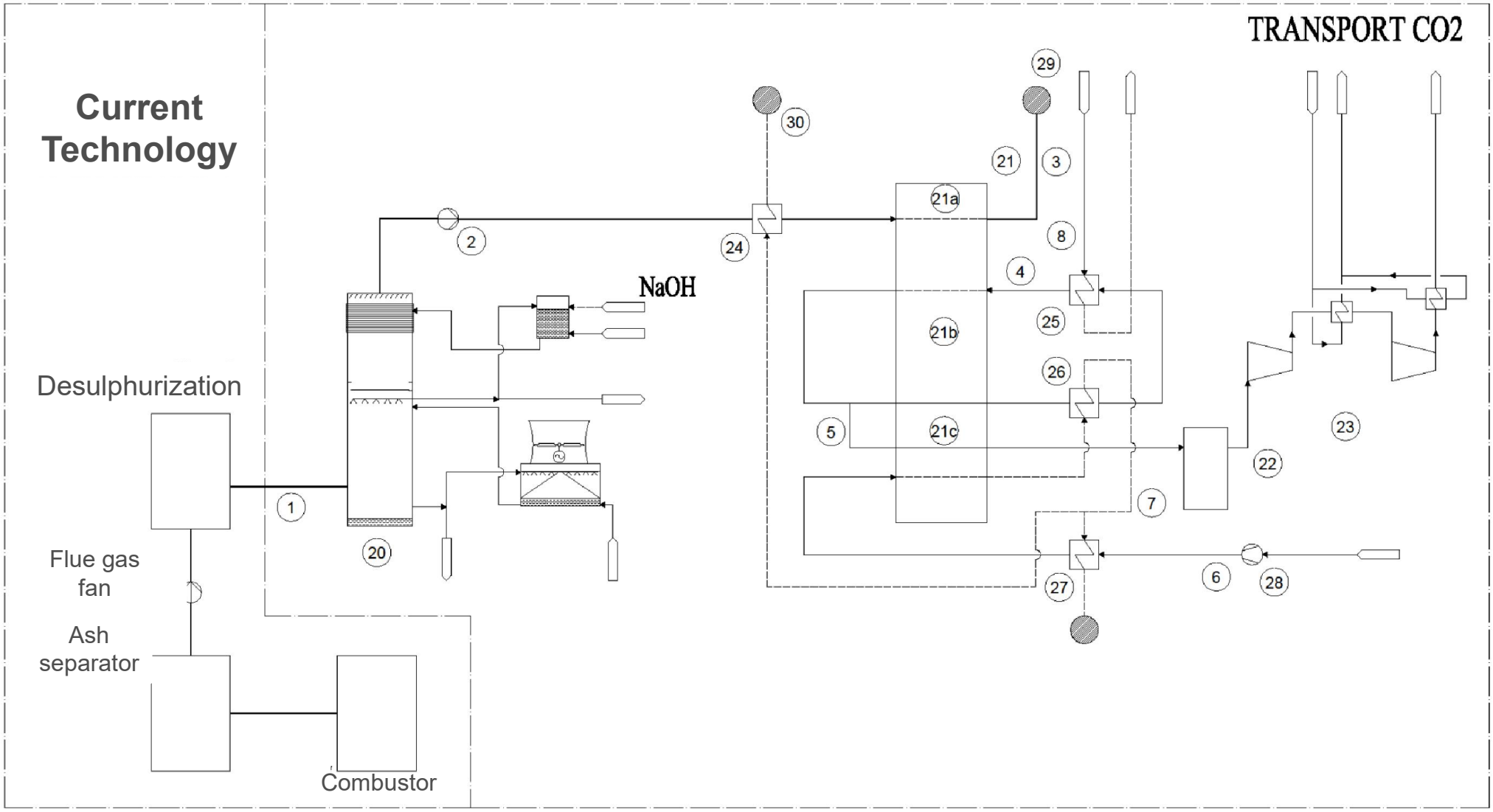
- Calcium loop
- Ashes with high residual content of CaO/CaCO3 could be used as a sorbent for calcium loop
- Free adsorbent
- Lower sorption capacity

UJV Activities

- **Economical study done in 2015 by UJV, comparison of low-temp. adsorption (maximum sorbent capacity for CO2 25 mg/g), ammonia scrubing and oxy-fuel**
  - Result: Low-temperatue adsorption is the most economically viable variant in 3 of 4 economical parameters:
    - Cost of electricity by 15 – 18 %
    - Cost of separated ton of CO2 by 40 – 45 %
    - CAPEX by 12 – 17 % (compared to other variants)
    - OPEX – best variant was oxy-fuel by 5 %
  - Cost of separated CO2: 20 USD/t
  - Cost of electricity manufacture increased by 30 %
  - Calculations were done for comercial sorbent
  - Main economical advantages of low-temp. sorption:
    - Relatively simple apparatus – low investment costs
    - Utilization of low-temperature steam for desorption (low cost, low energy efficiency drop)
  - Better sorbent capacity = better economical parameters

UJV activities – commercial utilization

- **Focused on low-temperature adsorption (based on the results of the economical study)**
- **Possible market use of CO2 (partial)**
- **Estimated costs of Transport + Geological storage is 20 – 30 %**
- **Estimated benefit of the CCS unit:**
  - The gain from CO2 sales
  - Emission allowances


Current Technology
TRANSPORT CO2
Desulphurization
Flue gas fan
Ash separator
Combustor
NaOH
1
2
3
4
5
6
7
8
20
21
21a
21b
21c
22
23
24
25
26
27
28
29
30

UJV activities

- **Issues to solve:**
  - Limited CO2 market (compared to CO2 production of power plants) – only part of CO2 captured could be sold
  - The CO2 purity after desorption (real flue gas) – limitations on possible applications
    - Technical CO2: 99,5 %
    - Food industry CO2: 99,9 %
- **Plan: experimental unit to investigate the purity of desorbed CO2**

Thank you

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