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LUAT

Lehrstuhl für Umweltverfahrens-technik und Anlagentechnik

Univ.-Prof. Dr.-Ing. habil. Klaus Görner

Post Combustion Capture

CCT 2009
Dresden
19.05.2009

Folie 1

Evaluation of Integration of Flue Gas Scrubbing Configurations with MEA for CO_2 Separation in a Coal-Fired Power Plant

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Folie 2

Overview

1. Boundary conditions for study
2. Power plant
3. CO_2 capture unit with compressor
4. Definitions
5. Results
6. Conclusions

Boundary conditions for study

Power plant (EBSILON®Professional)

- Advanced coal-fired power plant (anthracite)
- 600 MW_{el}
- 45.9 % efficiency (LHV)

Scrubbing unit (Aspen Plus 2006.5)

- 90 % CO_2 capture
- 30 % MEA solution

Compression (Aspen Plus 2006.5)

- 5 stages
- 100 bar

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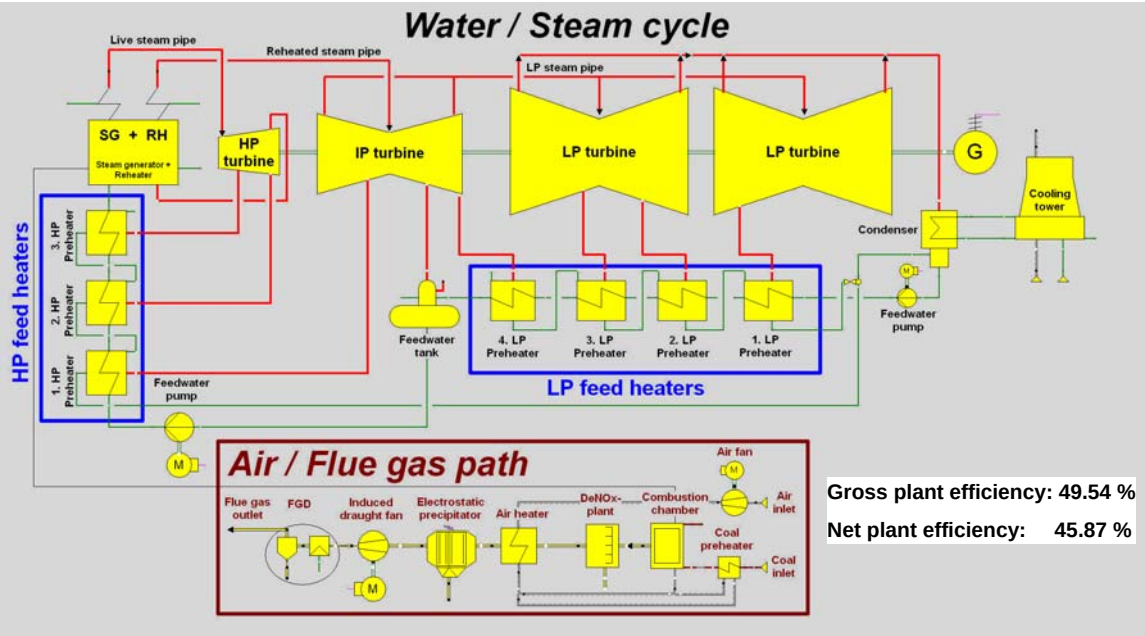
Power plant: Reference power plant North Rhine-Westphalia (RPP-NRW)



Gross power output:	600.0 MW	Live steam flow:	432 kg/s
Net power output:	555.6 MW	Live steam parameter:	600°C / 285 bar
		Reheated steam parameter:	620°C / 66 bar
		Condenser pressure:	45 mbar

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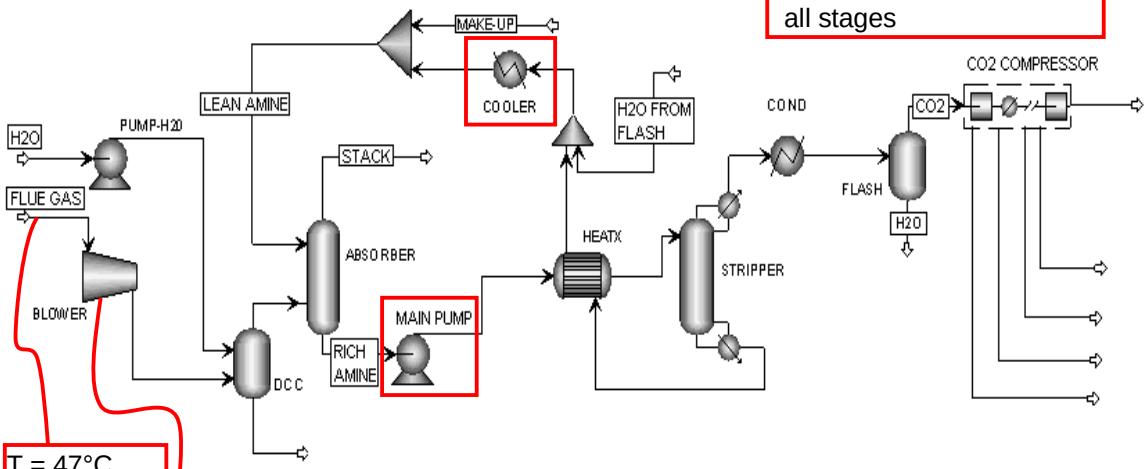
CO_2 capture unit with compressor

Stripper:
- 1.6 bar at the top
- 2.0 bar at the bottom

Compressor:
- T_{in} = 50°C
- Pressure ratio = 2.287 for all stages



T = 47°C

10 ppmv SO_2

Δp = 80 mbar

Absorber:
- Atmospheric pressure
- T_{in} = 40°C for both solvent and flue gas

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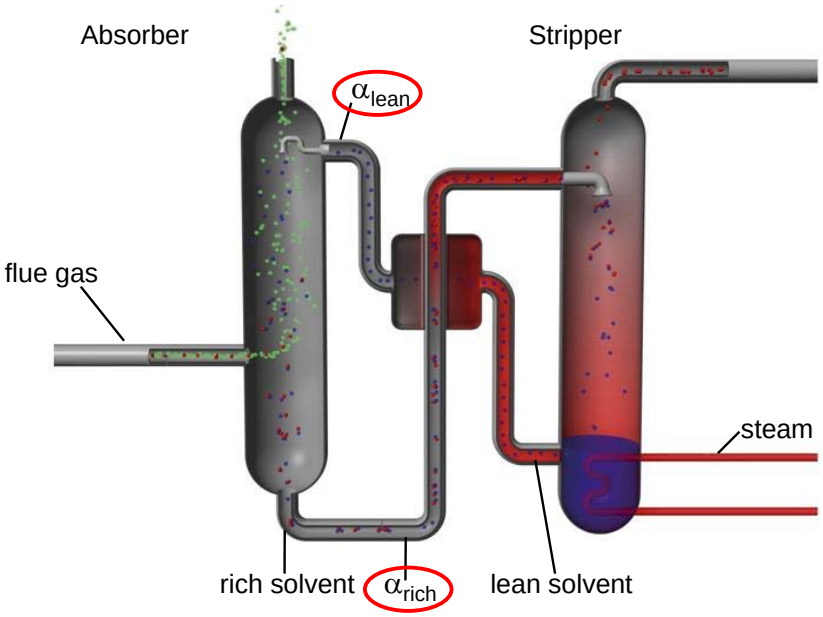
Definitions: Solvent loading (α) and $\Delta\alpha$

Solvent loading (α)

$$\alpha = \frac{mol_{CO_2}}{mol_{MEA}}$$

$$\Delta\alpha = \alpha_{rich} - \alpha_{lean}$$



Definitions: Why $\Delta\alpha$?

Desired objectives

- Optimal range of values for α_{lean}
- High α_{rich} preferred
- High capture rate with low energy demand for regeneration

Dependencies

- Reboiler duty = f($\Delta\alpha$)
- Solvent mass flow
- Electricity demand
- Cooling duty

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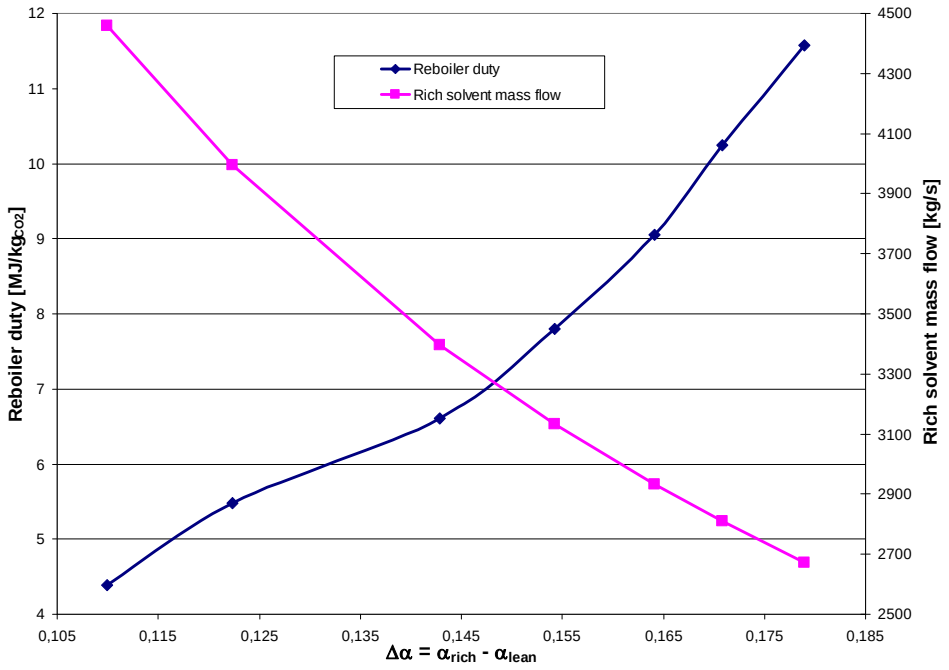
Results: Restrictions for process integration

- For 30 % MEA solution and conventional absorber-stripper configuration:
  - p_{steam} = 3.6 bar and T_{steam} = 140°C
  - Required steam conditions between intermediate and low pressure turbine
  - Reinjection of steam between third and fourth water preheaters
- Retrofitting of conventional power plant at specific energy demand of 3 MJ/kgCO_2 or lower

Results:
Reboiler duty and rich solvent mass flow as a function of Δα



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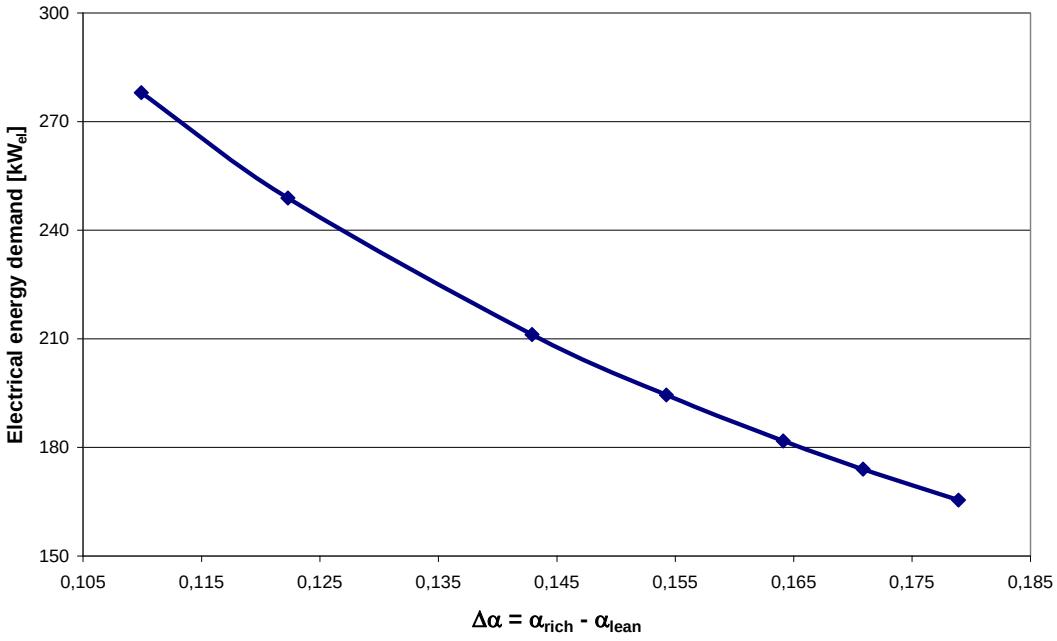
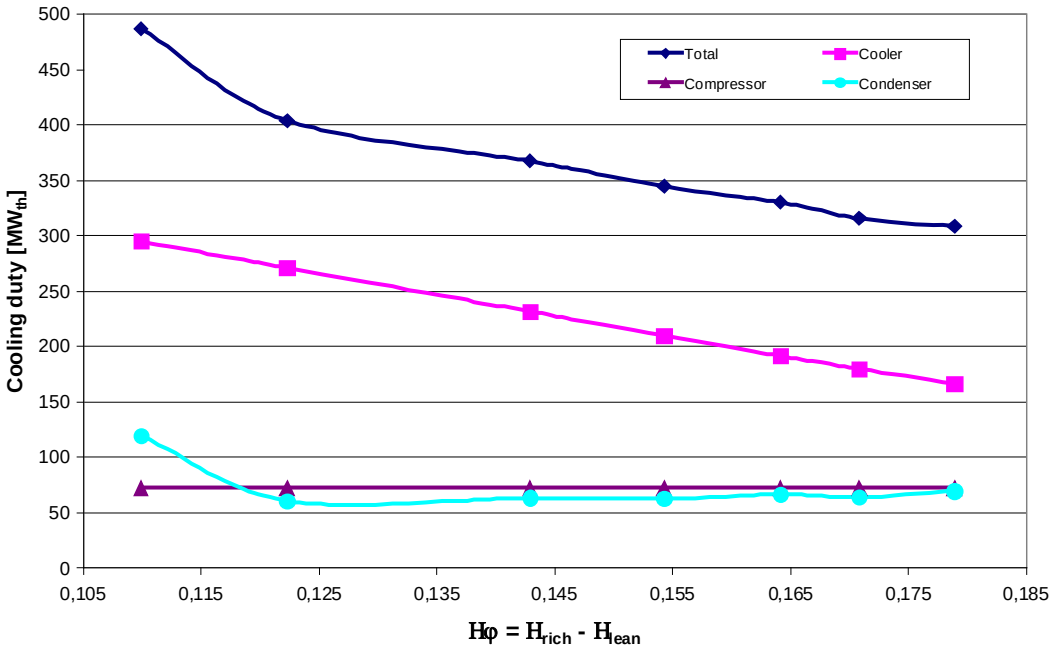
Results:
Electrical energy demand of the main pump as a function of Δα



Results: Cooling duty as a function of $\Delta\alpha$



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Folie 12

Conclusions: Scrubbing unit

- lean loading (α_{lean}) alone does not guarantee a reduction of thermal energy for regeneration of solvent
- small values of $\Delta\alpha$ increase demand of electricity, however the increase is considered small compared with blower and compressor
- for small values of $\Delta\alpha$ a higher cooling water demand is required
- minimum reboiler duty from simulation of 4.39 MJ/kg$_{CO2}$ however presented trends show that an even lower reboiler duty could be reached. First simulation results delivered a reboiler duty of 3.25 MJ/kg$_{CO2}$ but there seem to be some instabilities that have to be further studied. Implemetation of latest software could contribute to solve this problem.
- testing of solvent(s) under real conditions required for its application in coal-fired power plants
- a reduction potential of approximate 1 MJ/kg$_{CO2}$ could be achieved by optimising heat recovery within the scrubbing process

Conclusions: Power plant

- Three options for steam extraction from power cycle:
  - Build in a throttle, which would be essential to guarantee needed steam parameters from scrubbing unit, causing additional losses within the power cycle
  - Remodel of turbines
  - Not to modify the cycle and instead provide the steam from external source

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Thank you for your attention