# Estimation of Corrosion Risks Caused by Alkali-Species in Oxyfuel Processes

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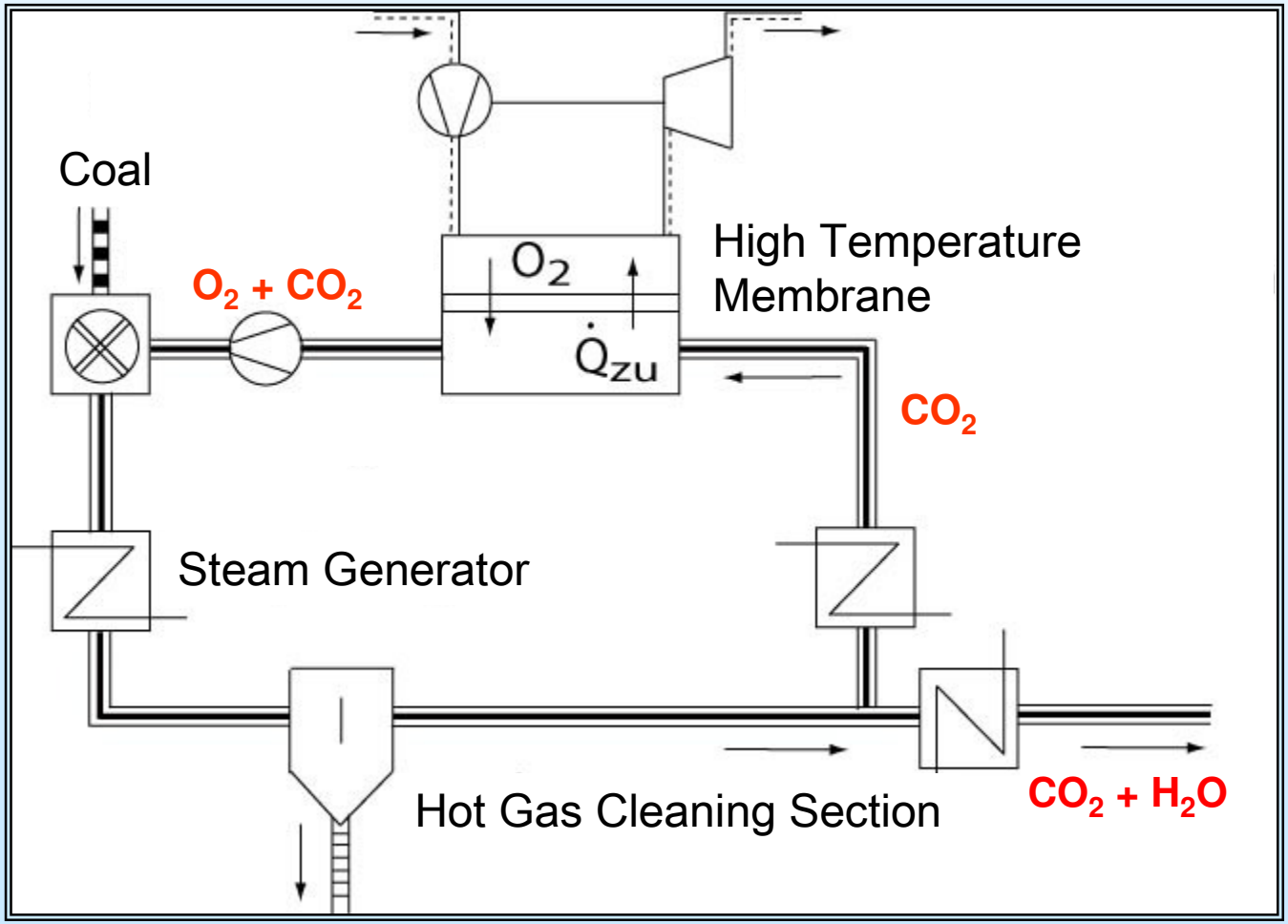
# Outline

- The OXYCOAL-AC process
  - Calculations with FactSage
  - Process modelling with SimuSage
- The POxycoal process
  - Calculations with FactSage
- Conclusions

# The OXYCOAL-AC Process

Coal fired power plant concept using oxyfuel technology

# The OXYCOAL-AC Process




www.oxycoal-ac.de

# Hypothesis

- Exchange of nitrogen (air) by carbon dioxide (flue gas)
- Fraction of available $CO_2$ increases strongly

**=> change of combustion and hot gas chemistry**

- Condensation/precipitation of alkali-containing carbonates may be enforced

**=> severe hot corrosion of tube materials**
=> fouling of the membrane
=> plugging of the hot gas filter

# Calculations with FactSage

# Input Data

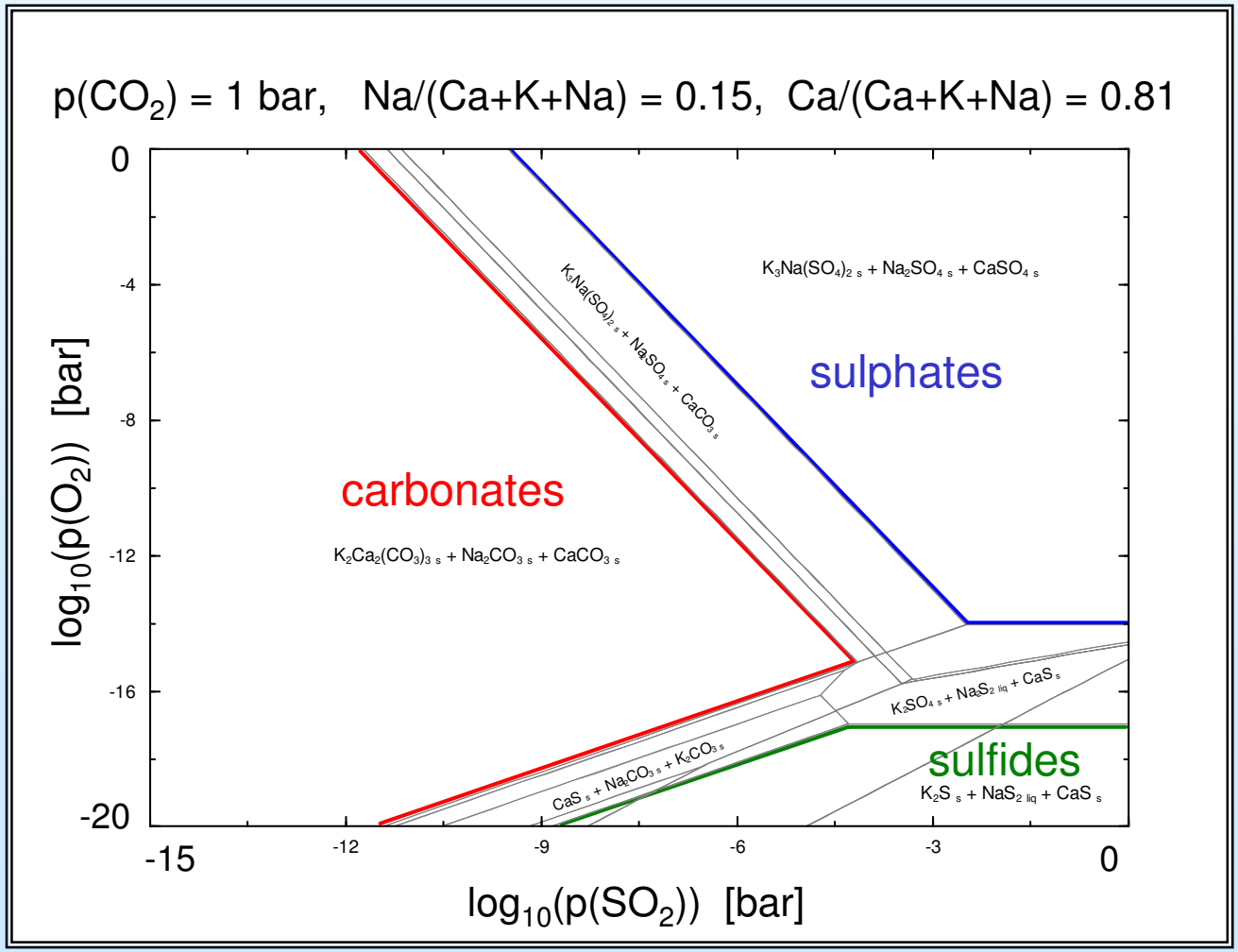
- **Hard coals** from the German Ruhr coal-mining area:

| | | |
|---|---|---|
| hard coal | (Ca+Na+K) / S | 0.5 to 2.2 |
| | (Ca+Na+K) / (Si+Al) | 0.15 to 0.5 |

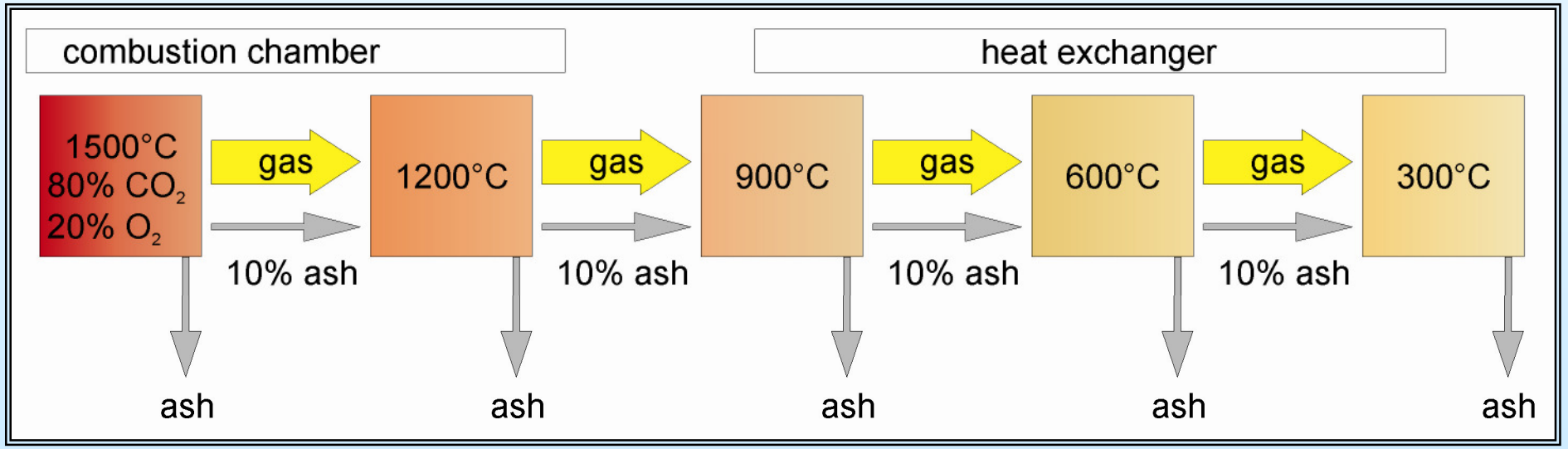
- **Brown coals** from the German Rhenish coal-mining area:

| | | |
|---|---|---|
| brown coal type 1 | (Ca+Na+K) / S | 2.0 to 3.8 |
| | (Ca+Na+K) / (Si+Al) | 1.2 to 5.7 |
| brown coal type 2 | (Ca+Na+K) / S | 2.0 to 3.5 |
| | (Ca+Na+K) / (Si+Al) | 26.5 to 27.7 |

# Predominant Phases in the K-Na-Ca-S-O-C-System for Brown Coal at 800 °C



# Thermodynamic Modelling of the OXYCOAL-AC Process with FactSage



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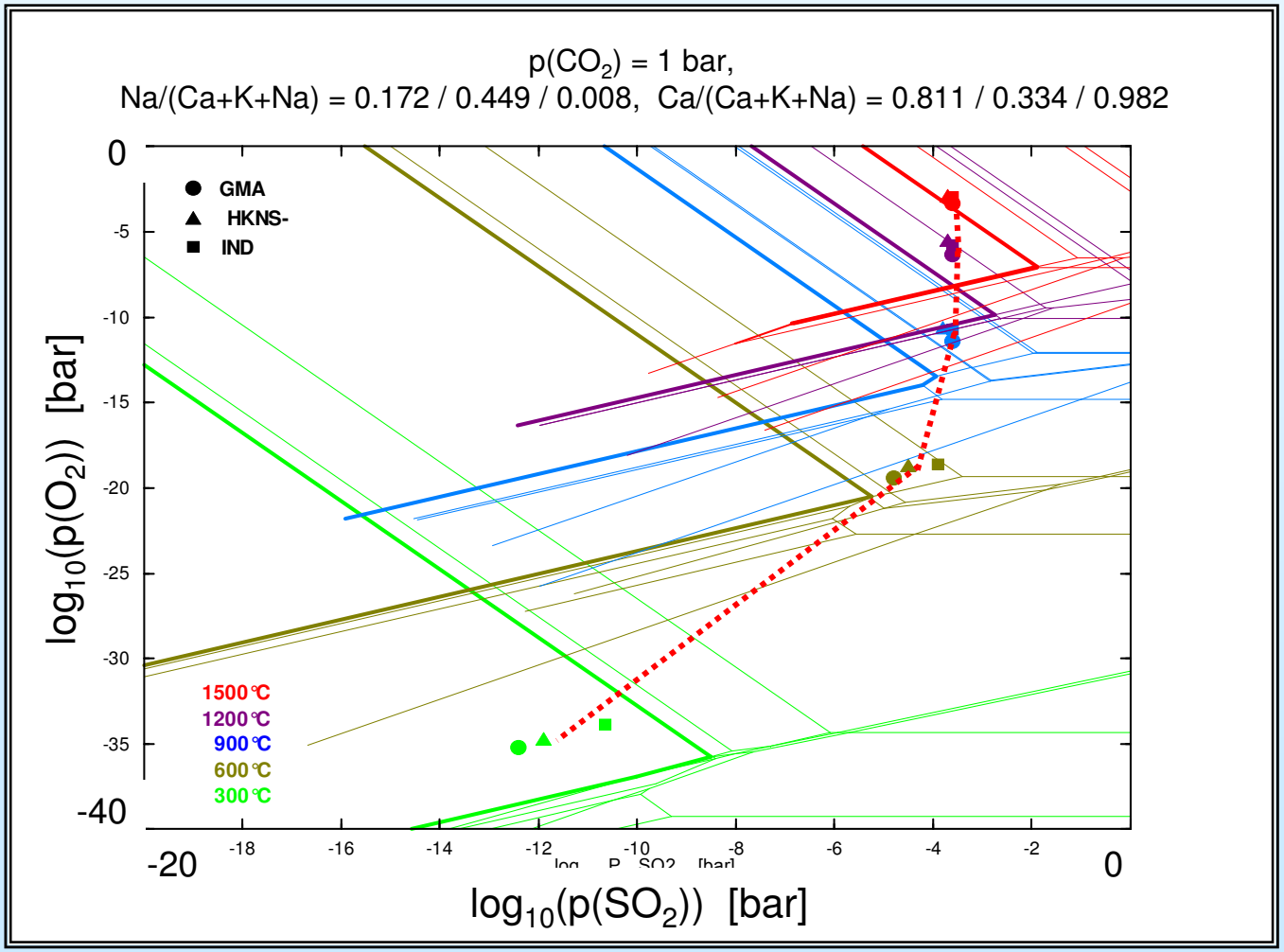
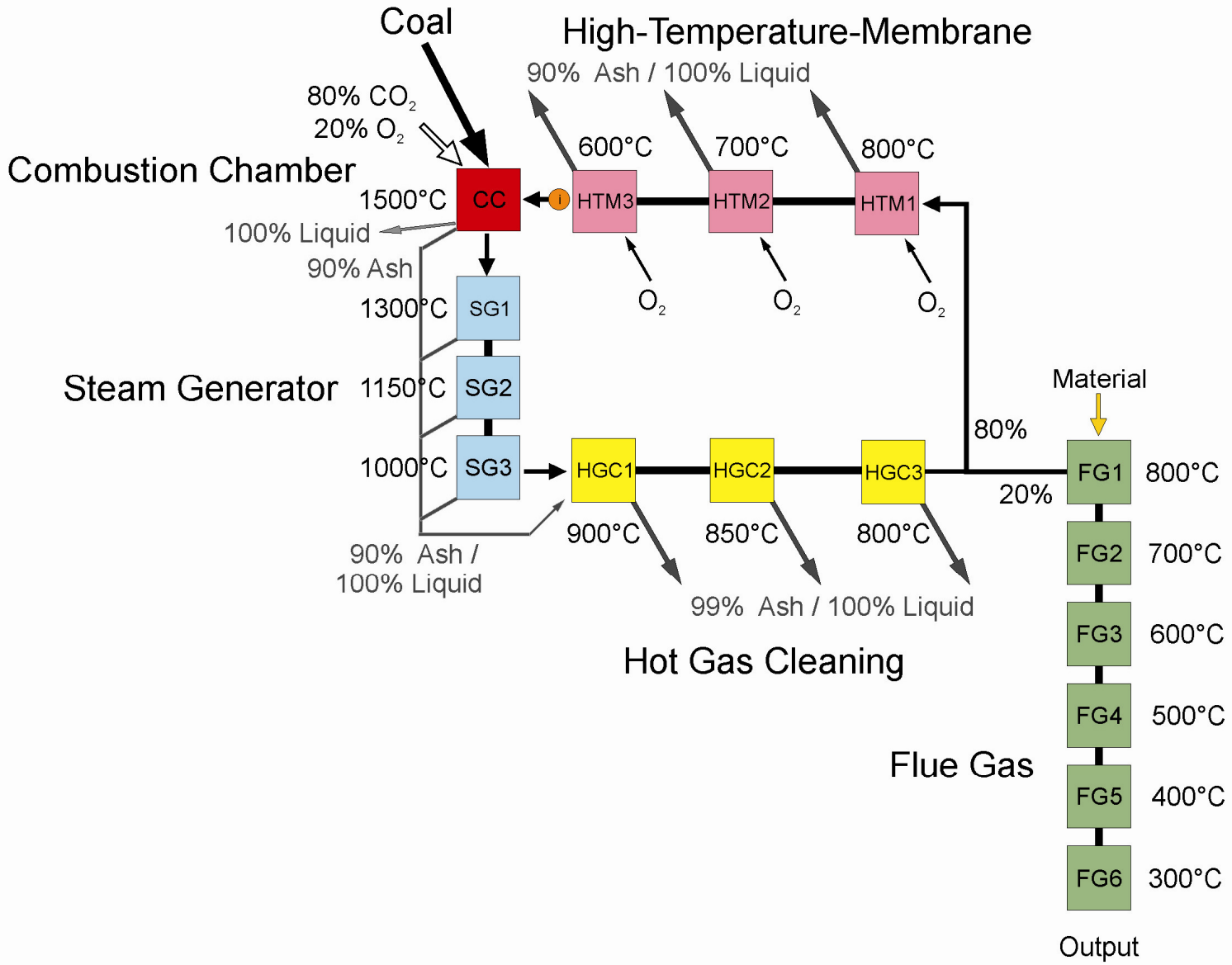
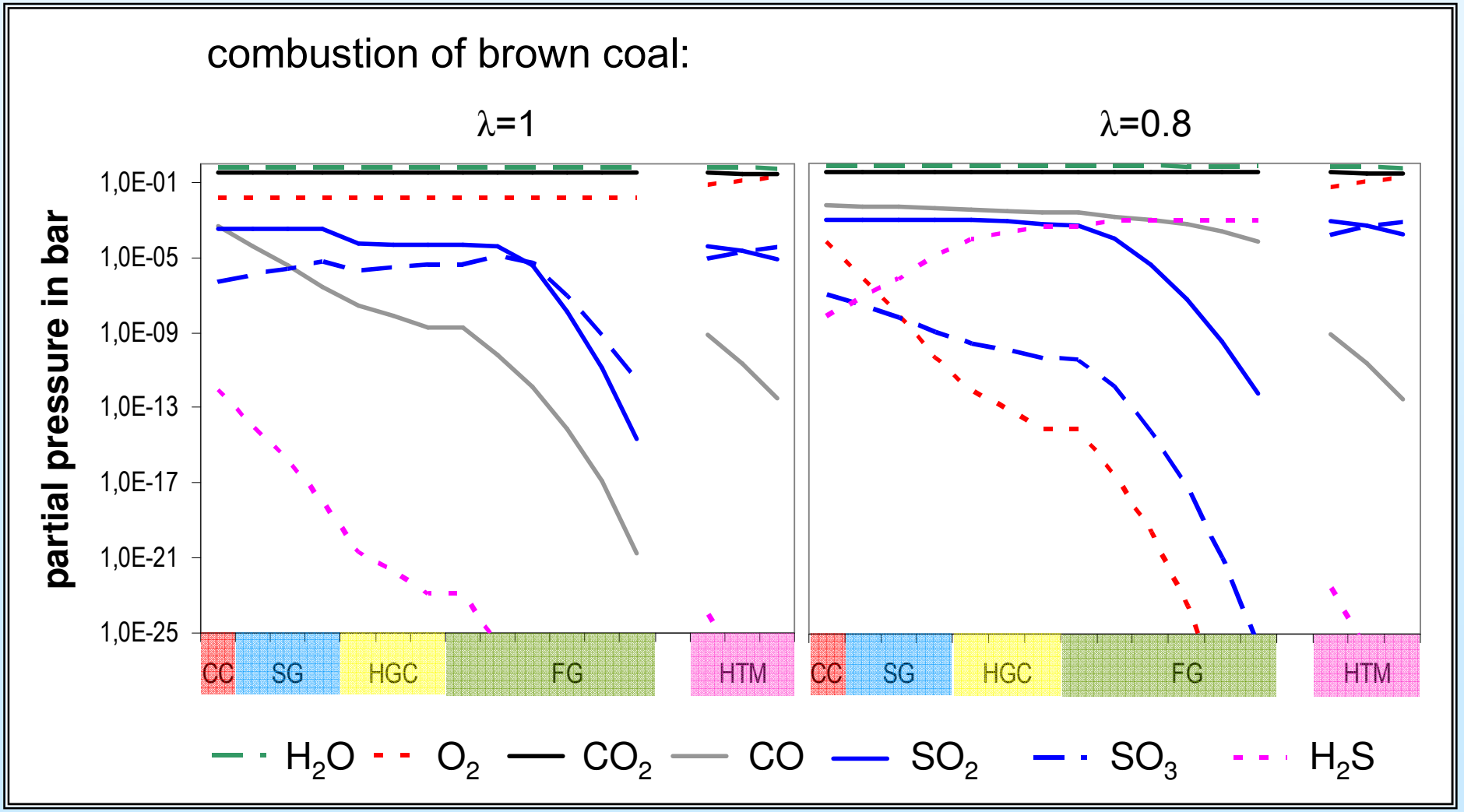


# The SimuSage Model

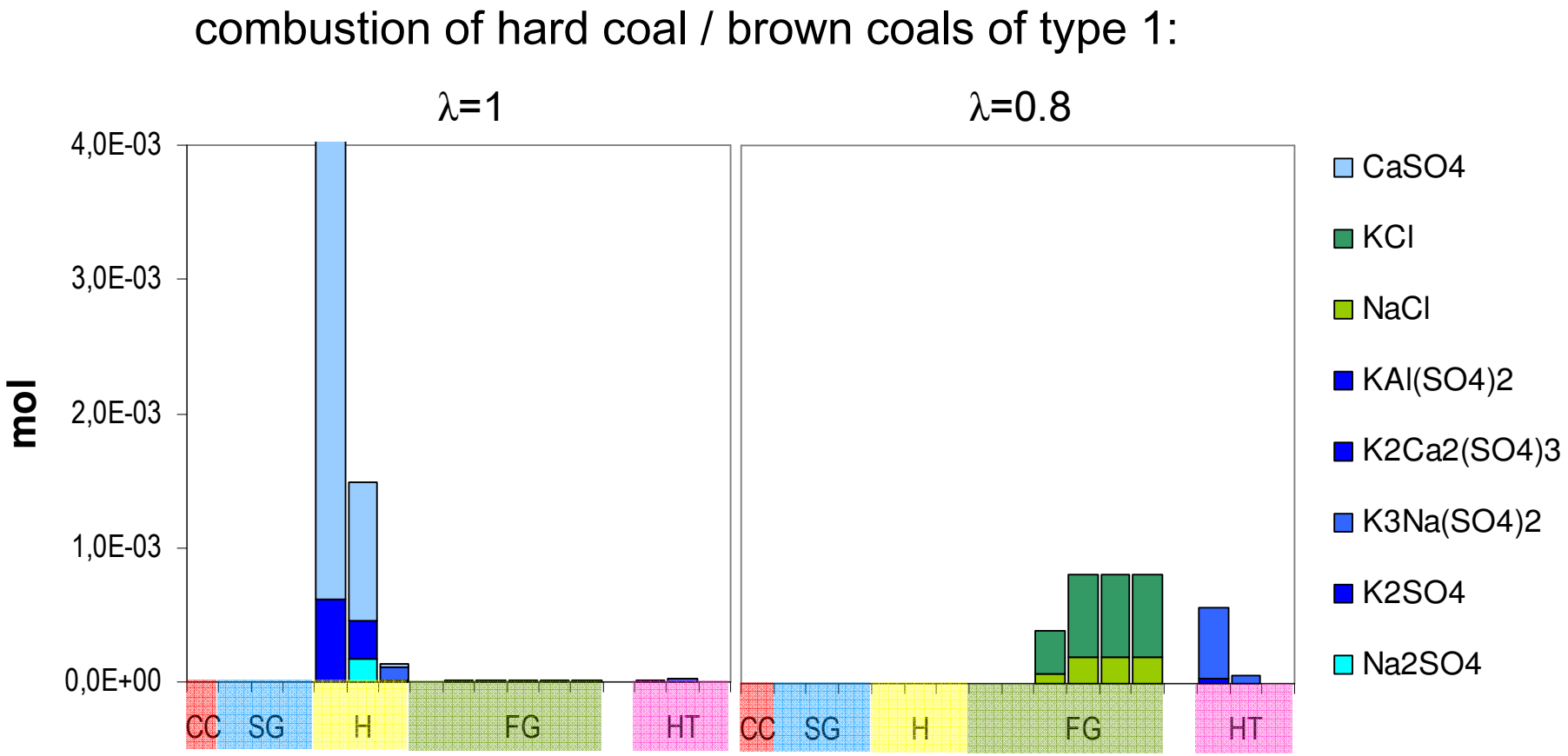

Coal
High-Temperature-Membrane
90% Ash / 100% Liquid
80% $CO_2$
20% $O_2$
600°C
700°C
800°C
Combustion Chamber
1500°C
CC
HTM3
HTM2
HTM1
100% Liquid
90% Ash
$O_2$
$O_2$
$O_2$
1300°C
SG1
Steam Generator
1150°C
SG2
1000°C
SG3
HGC1
HGC2
HGC3
80%
20%
Material
FG1
800°C
FG2
700°C
FG3
600°C
FG4
500°C
FG5
400°C
FG6
300°C
900°C
850°C
800°C
90% Ash /
100% Liquid
99% Ash / 100% Liquid
Hot Gas Cleaning
Flue Gas
Output

# Results

# Composition of the Flue Gas



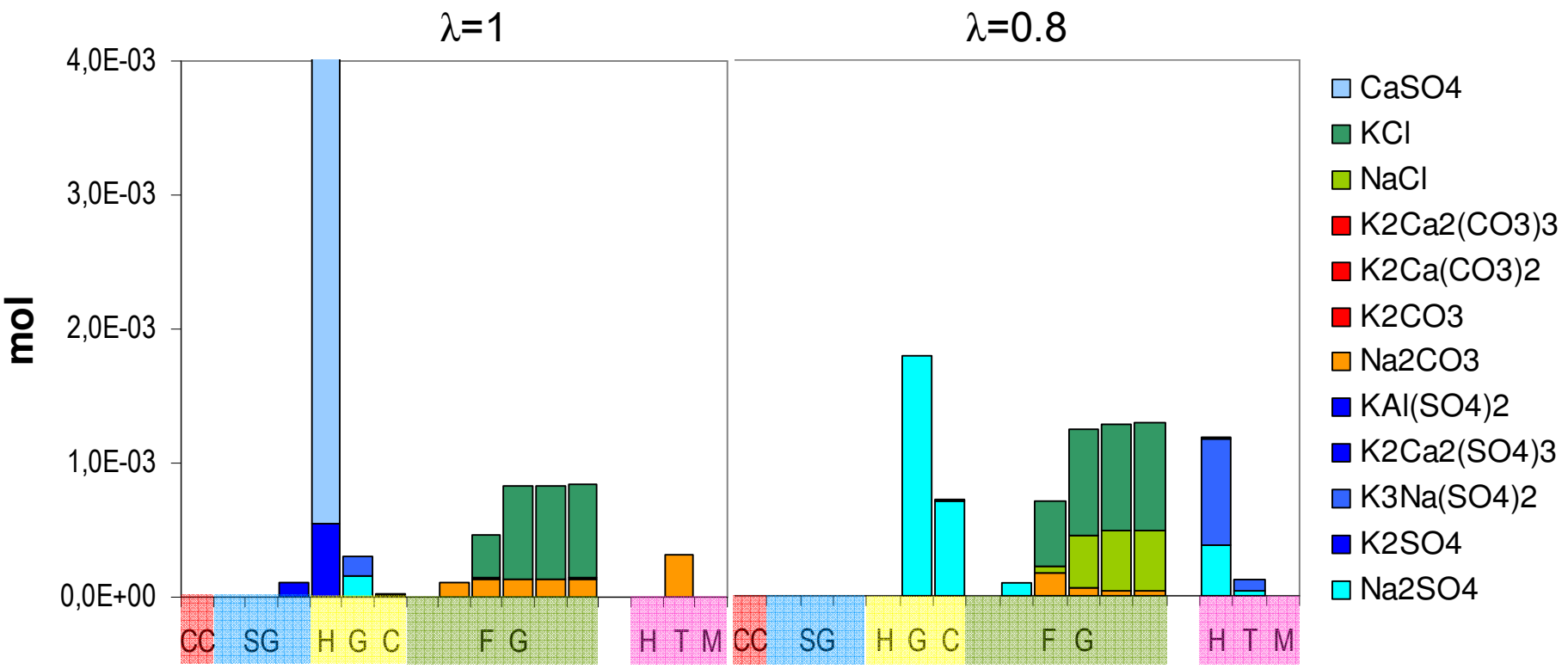
# Composition of the Ashes




> **Sulphates** and **chlorides** occur

# Composition of the Ashes

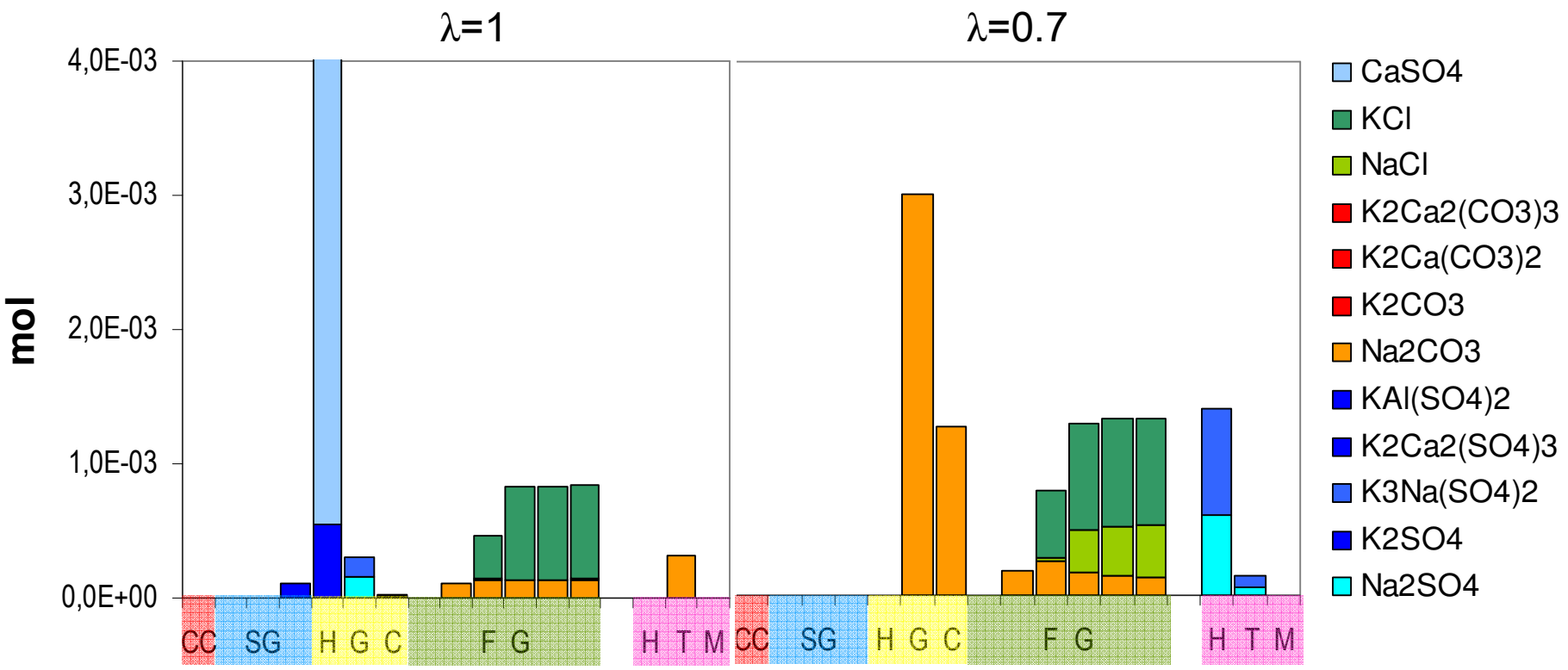
combustion of brown coals of type 2 (Si- and Al-poor):




> **Carbonates** occur additionally to sulphates & chlorides

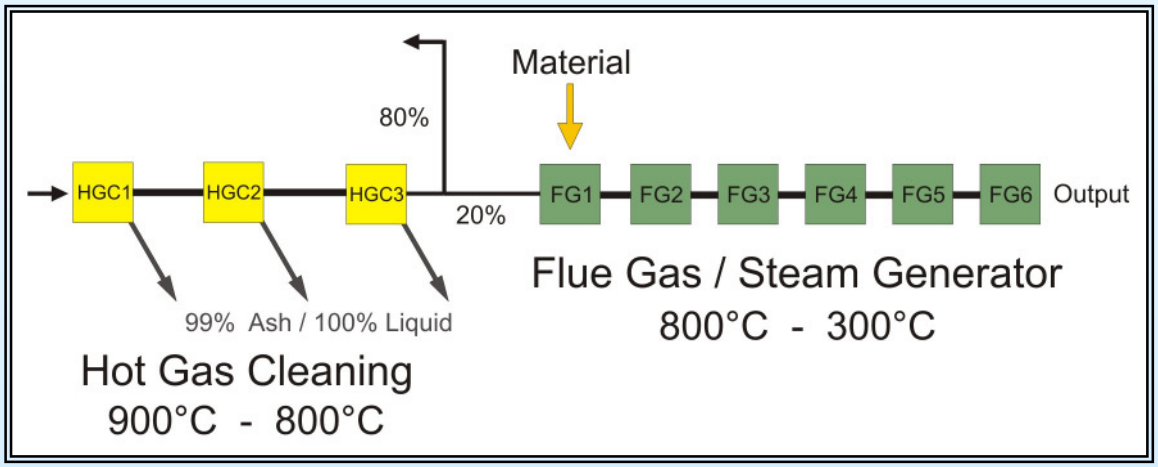
# Composition of the Ashes

combustion of brown coals of type 2 (Si- and Al-poor):




> **Carbonates & chlorides** dominate at λ=0.7

# Interactions between Tube Material and Flue Gas




Tube material:
nickel-base alloys

in the model: **Ni**

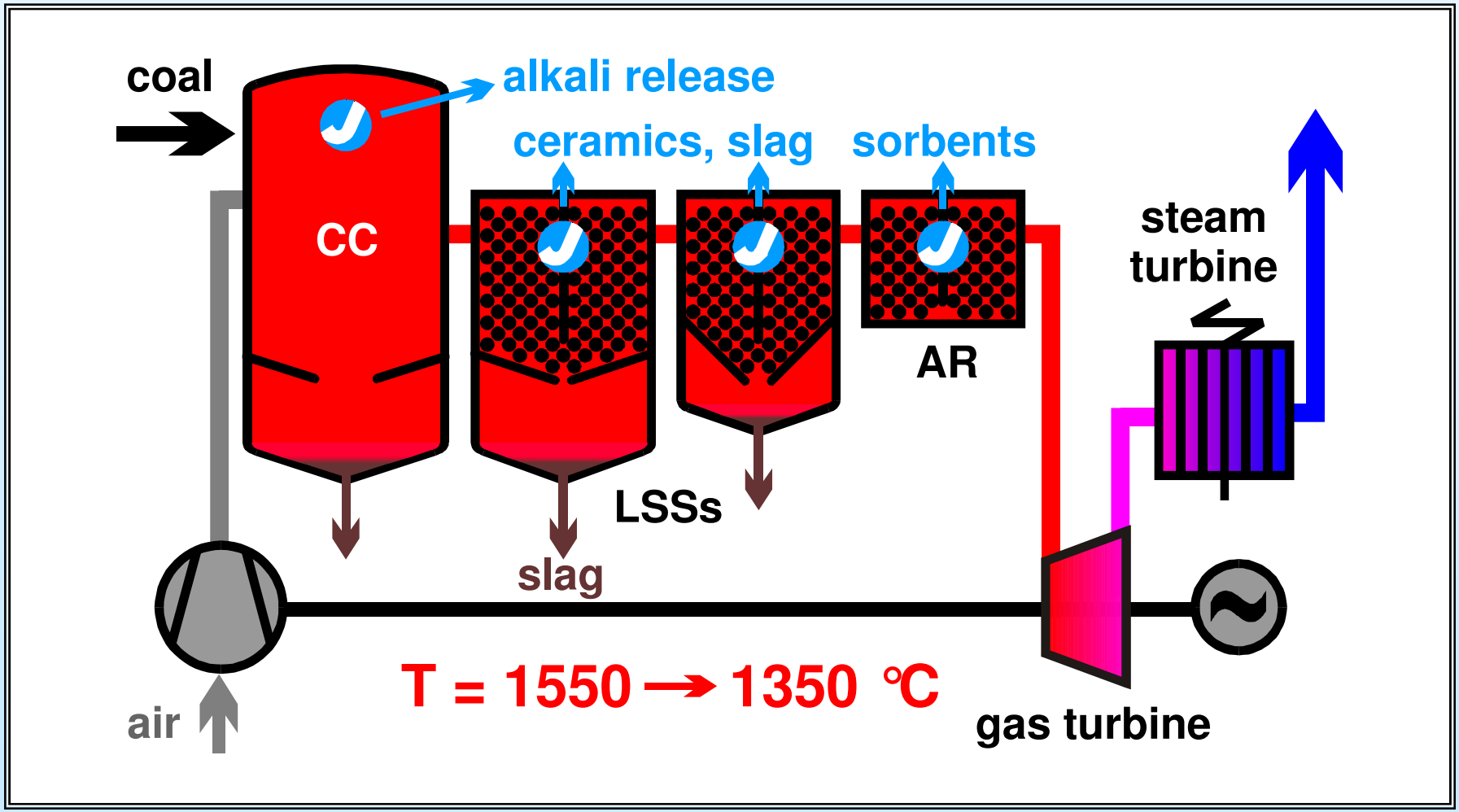
- Stoichiometric combustion conditions:
  $NiO$, $NiSO_4$ => **sulphate induced corrosion**

- Sub-stoichiometric combustion conditions:
  $Ni_3S_2$, $NiS$ => **sulphidation of nickel**

# The POxycoal Process

PPCC process under conditions of oxyfuel - POxycoal

# Pressurized Pulverized Coal Combustion



# Hypothesis

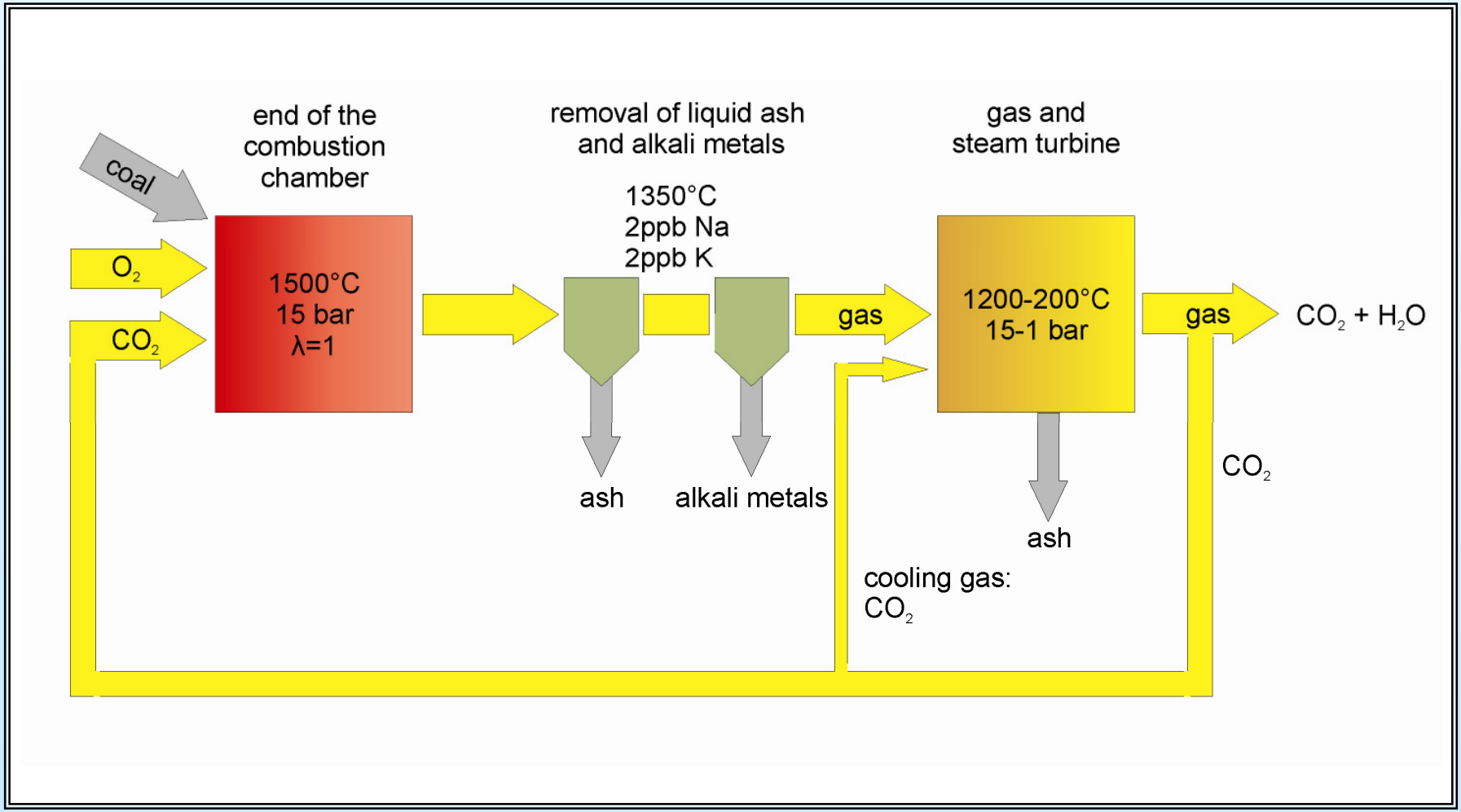
- Recycling of the flue gas before desulphurisation

**=> increase of the sulphur content in the flue gas**

- Condensation of alkali-containing sulphates may occur at high temperature and pressure conditions
- Eutectic melting conditions of Ni- and Na-sulphates may be reached

**=> severe hot corrosion of turbine blade materials**

# Thermodynamic Modelling of the PPCC Process under Conditions of Oxyfuel - POxycoal



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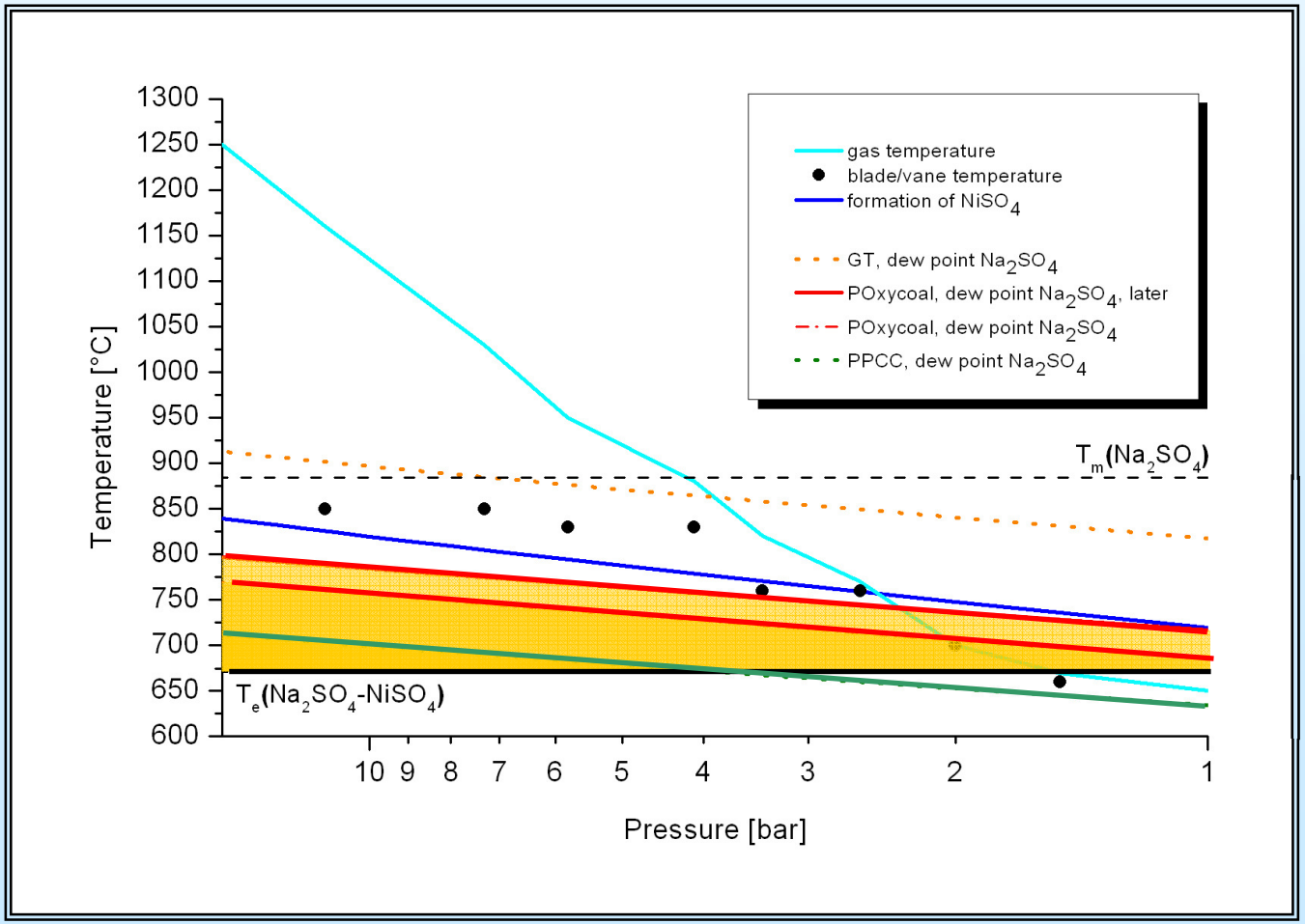

# Conclusions

# Conclusions – OXYCOAL-AC

- The **oxygen content** of the flue gas plays a significant role concerning the formation of alkali-containing compounds.

=> It influences at a high level the **stability of sulphates** and therefore the **instability of carbonates.**

- Carbonates may precipitate at a sub-stoichiometric combustion of Si- and Al-poor brown coals ($\lambda \leq 1$).

=> Potential risks of **corrosion of the tube materials** are indicated by the formation of alkali containing solid phases and the interaction between the material and the flue gas

# Conclusions – POxycoal

- The **sulphur content** of the flue gas gets concentrated by the recycling of the flue gas in the process

=> The **formation of sulphates** occur at higher temperature and pressure conditions

- Alkali metal containing sulphates precipitate at temperatures higher than the eutectic melting temperature of Ni- and Na-sulphates

=> Potential risks of sulphate induced **hot corrosion** of the **blade materials** have to be considered