REFAWOOD - Reduction of ash-related problems in large-scale biomass combustion systems via resource efficient low-cost fuel additives

Graz, 24.01.2020

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  - flue gas composition
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Introduction and objectives

- **Slagging and fouling in biomass fired boilers leads to shutdowns → Removement of these deposits**
  - **Downtime** of the boiler is associated with **enormous costs.**
- **Corrosion can damage the heat exchangers**
- **In order to minimise the slagging tendency and corrosion risk, inexpensive additives can be used.**
  - Additives and favourable additive rates were first tested on laboratory scale.
  - Aim: Testing of suitable additives in a large-scale biomass combustion system.

Introduction and objectives

- **Plant investigated**
  - 40 MW_{th} grate furnace equipped with 3 dust injectors; production of superheated steam
  - Fuel: grate: forest wood chips, bark and waste wood
    dust burner: dust fractions from the chipboard manufacturing process
  - Problems: slagging in the combustion chamber, slagging and fouling at the heat exchanger, corrosion

Introduction and objectives - Scheme of the biomass CHP plant

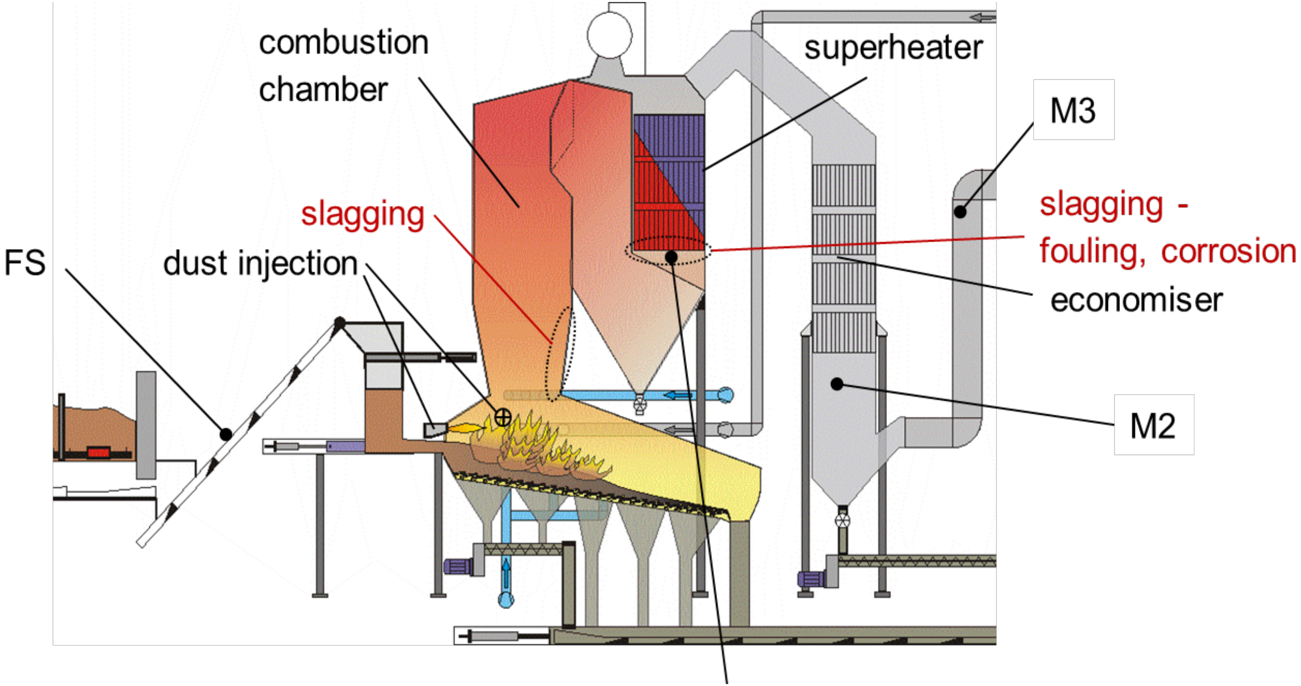
<u>Measurement and sampling points:</u>

FS … fuel sampling

M1 … deposit probe

M2 … flue gas analysis

M3 … total dust and aerosol concentrations



M1: 3rd duct (upstream superheater)

Introduction and objectives - Photos of problems in the biomass boiler

Protective evaporator from below (in the flow direction, luv) after a system operation of **9 weeks**

Rear wall of the 2nd duct against the flow direction after a system operation of **9 weeks**

Methodology

- **Additive injection above the grate close to the right dust injector**
- **Measurements**
  - Flue gas composition (SO_2, HCl, NO_x, CO); total dust; aerosols
  - Chemical analysis: fuel, bottom ash, total dust and aerosols
  - Deposit formation
    - Deposit probe simulating a heat exchanger tube
    - Determination of built-up rate
    - SEM/EDX analysis for composition of deposits

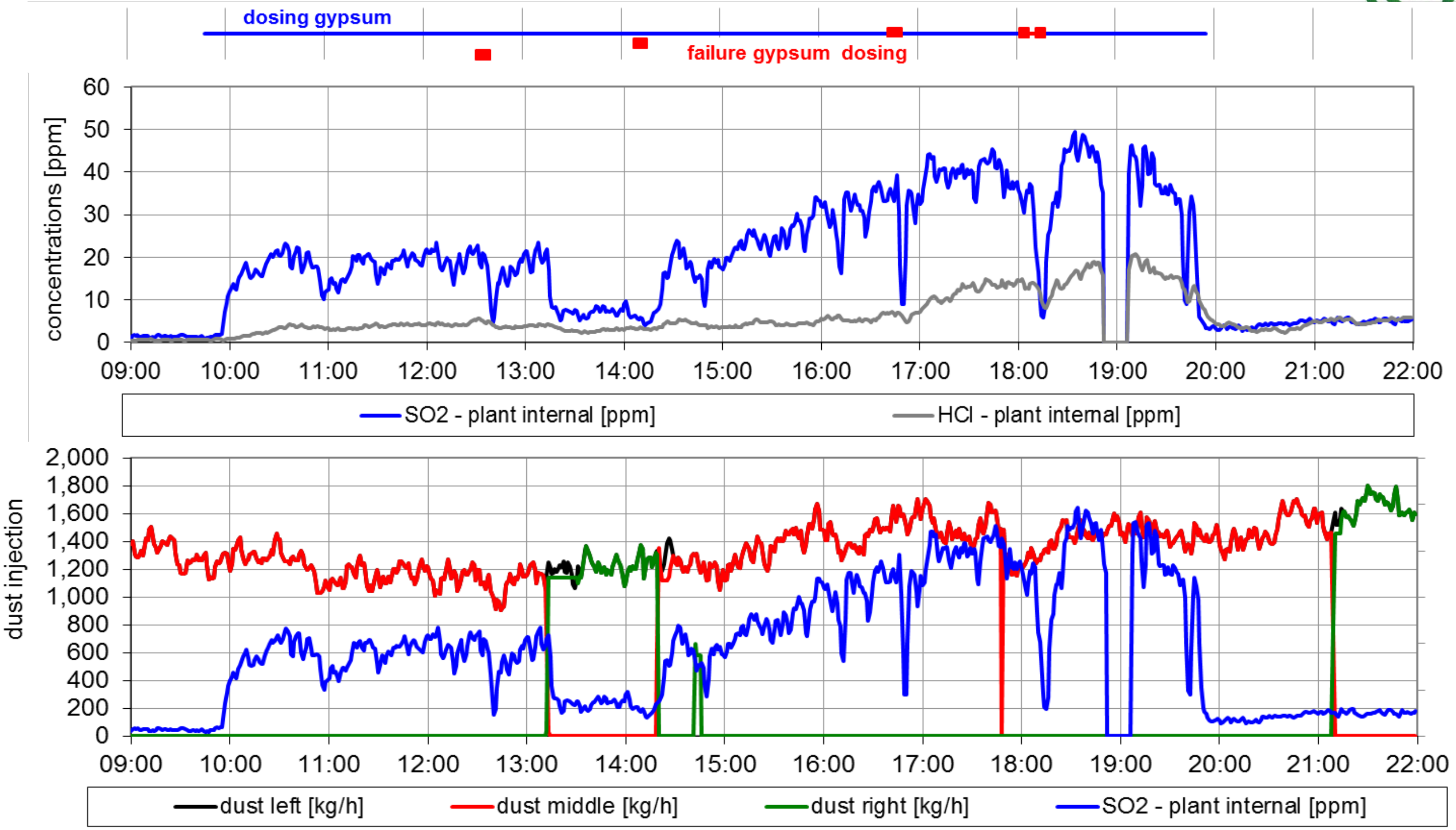
Methodology - Additive investigations

- **Additive application**
  - Reference without additive
  - Coal fly ash
  - Gypsum

- **Amounts of additive provided to the combustion system**

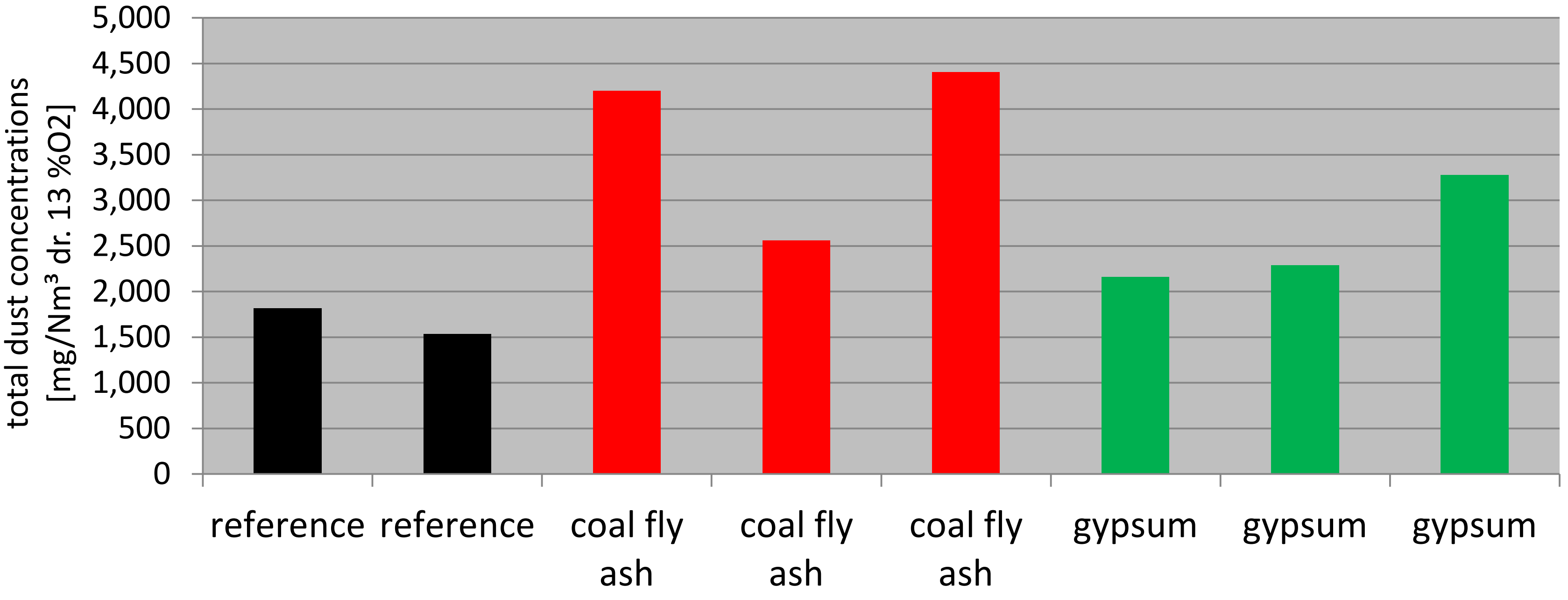
Additive	Addition in wt.% related to dry fuel	Addition in kg/min
Coal fly ash	3	3.92
Gypsum	2	2.61

Results - Flue gas composition – Gypsum addition



Results - Total dust measurements

- **Total dust concentrations in the flue gas**

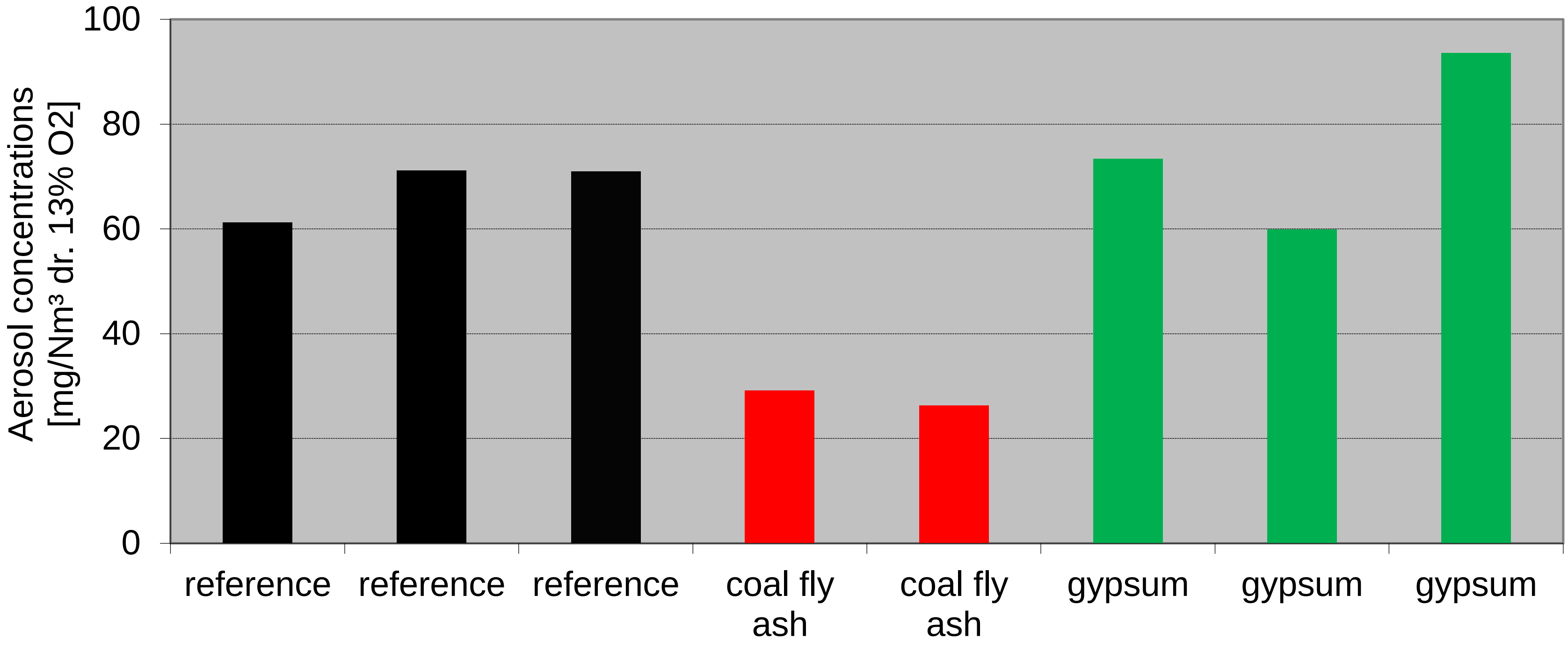


Results - Total dust measurements

- **Total dust in the flue gas – chemical composition**
  - **Higher Al** und **lower K and Zn** concentration for **coal fly ash** addition compared to the reference case without additive.
    - Coal fly ash contains high amounts of Al and reduces the release of K and partly of Zn
  - Significantly **higher S** concentrations and **lower Cl** concentrations for **gypsum** addition compared to the reference case without additive
    - Degradation of gypsum in the combustion chamber
    - Formation of SO_2 → formation of sulphates instead of chlorides

Results – Aerosol measurements

- **Aerosol concentrations in the flue gas**

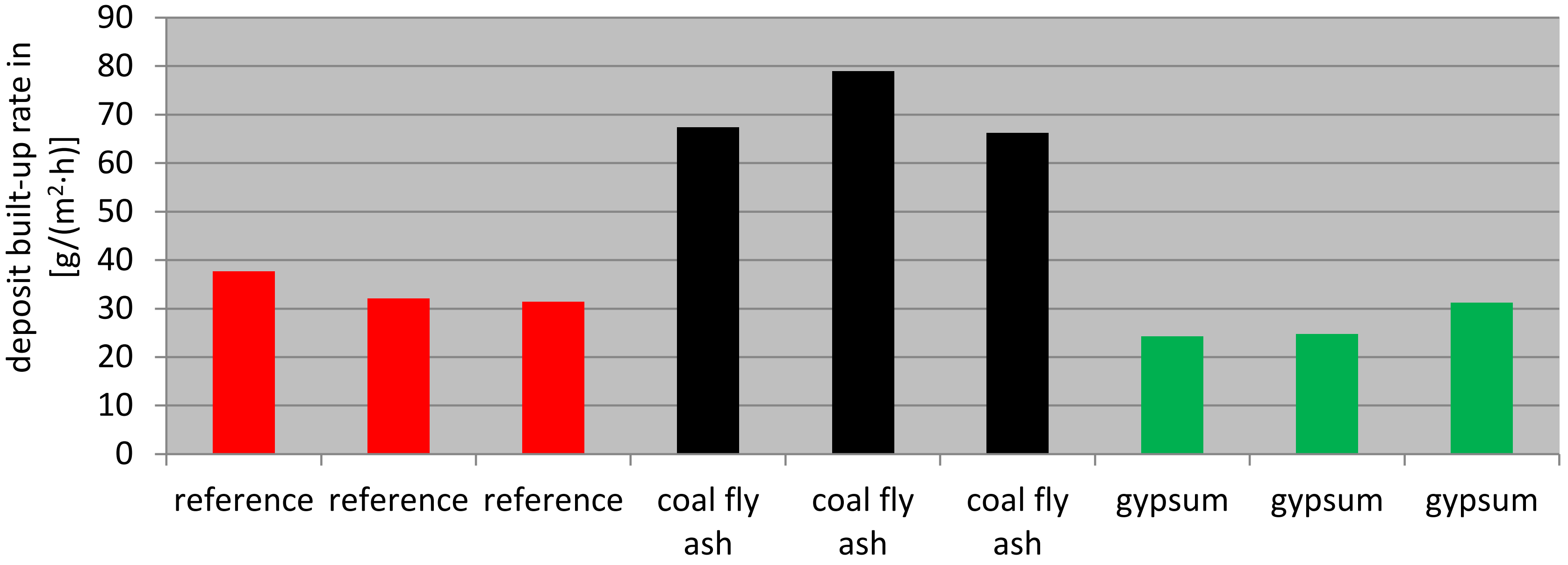


Results – Aerosol measurements

- **Aerosols in the flue gas – chemical composition**
  - **higher S** concentrations in the aerosols for **gypsum** addition
    - degradation of gypsum in the combustion chamber
  - **higher Si, Fe and Ca** concentrations in the aerosols for **coal fly ash** addition
    - High Si and rather high Fe concentrations in coal fly ash
  - **lowest K** concentration for **coal fly ash** addition
    - reduced K release by coal fly ash addition

Results - Deposit formation - Built-up rate

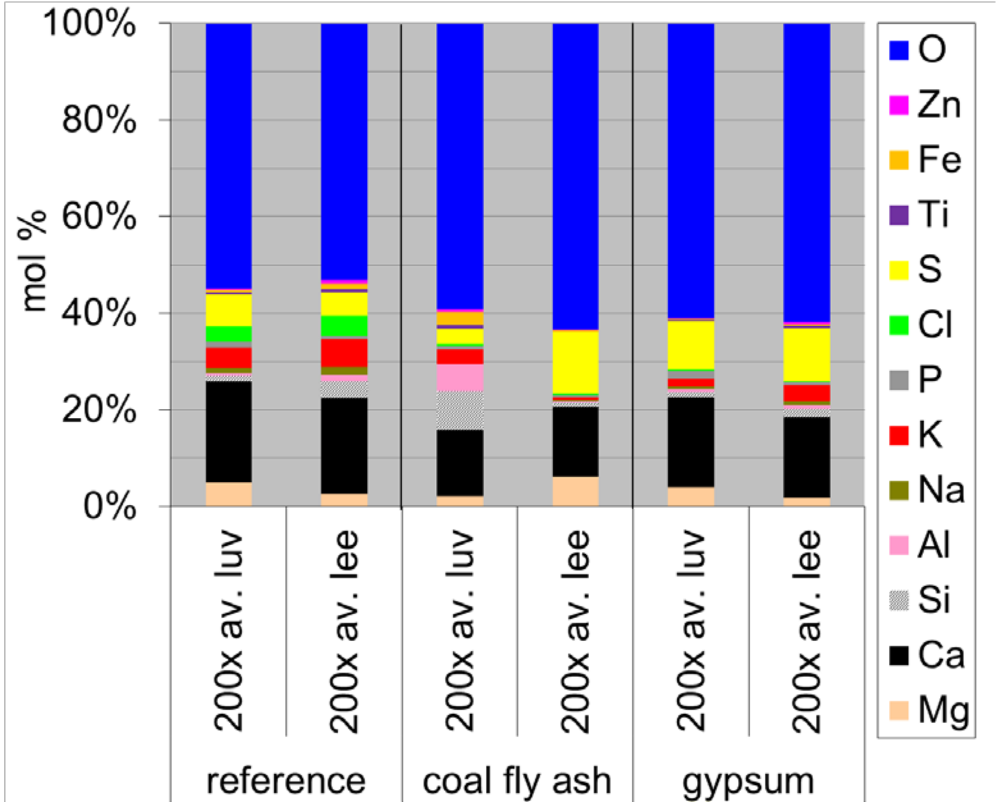
- **Deposit built-up**



- Highest deposit built-up rate for coal fly ash addition

Result - Deposit formation - Chemical composition

- **Reference**
  - Up to 4.1% Cl in deposits
- **Coal fly ash**
  - Increased Si and Al concentrations
  - Reduced Cl content
- **Gypsum**
  - Increased S concentrations
  - Almost no Cl (< 0.5%)



Results - Deposit formation – high temperature corrosion

■ Molar 2S/Cl ratios of the deposits

		reference	coal fly ash	gypsum
2S/Cl depositions	mol/mol	4.2	19.3	75.6

- **Moderate to high** high temperature corrosion risk for the reference case
- **Negligible** high temperature corrosion risk for additive application, especially for gypsum addition

Summary and conclusions

- **Position of additive injection and prevailing boundary conditions in the boiler (dust injection close to the additive injection) influences the precipitation of the additive in the boiler.**
  - Additive application must be individually tailored out to each specific combustion system
- **Degradation of gypsum in the combustion chamber successful**
  - Dust and aerosols comparable to reference case
  - Formation of SO_2 → formation of sulfates instead of chlorides
  - Reduced risk for high temperature corrosion

Summary and conclusions

- **Increased total dust concentrations for coal fly ash addition**
- **Increased deposit built-up rate for coal fly ash addition**
- **Higher S and lower Cl concentrations in the depositions for additive application → sulphation → lower high temperature corrosion risk**
- **Minimised aerosol concentrations for coal fly ash addition**
  - Reduced K (and Zn) release ratios

Thank you for your attention!

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