# $SO_3/SO_x$ ratio in oxy-fuel combustion – the impact of operational conditions

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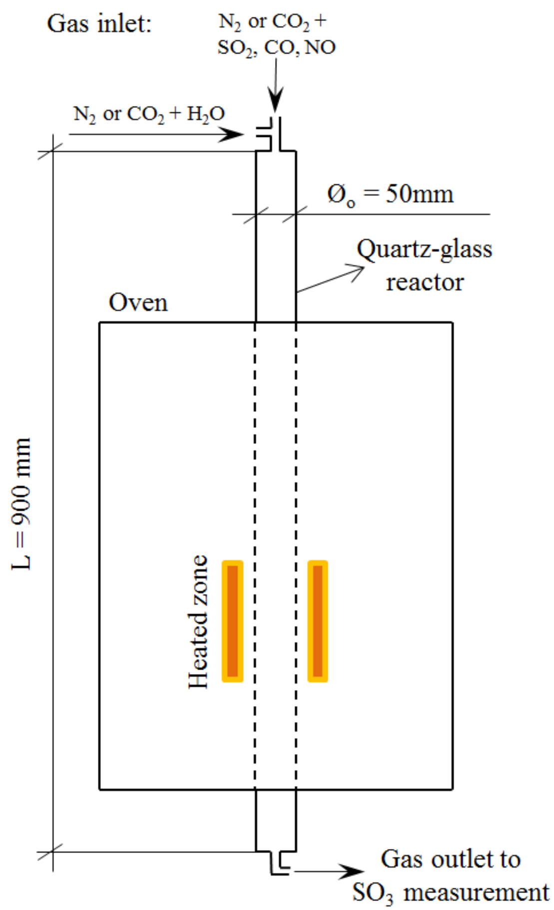
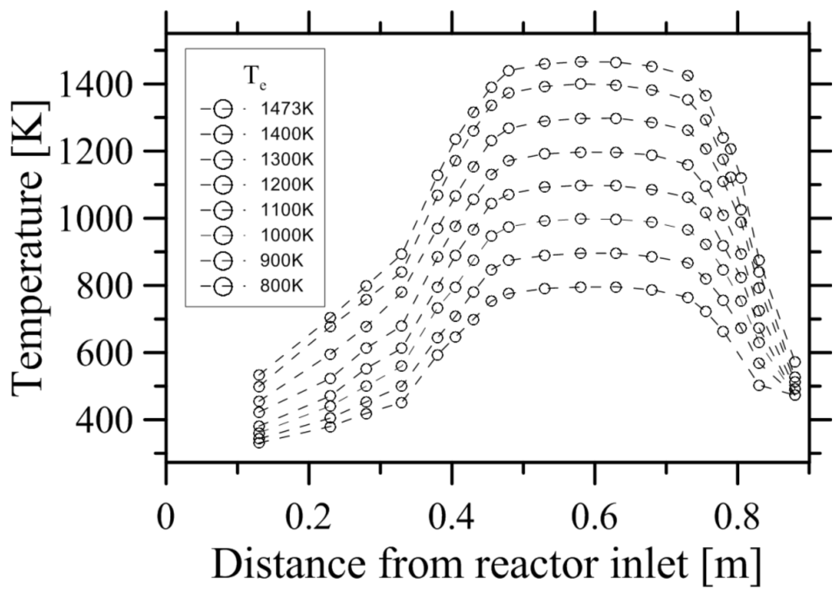
# Background

- **The role of gas-phase sulphur chemistry in HTC and LTC**
  - Sulphation of alkali via $SO_3$
  - Formation of sulphur-containing corrosive salts
  - Prevention of chlorine-based salts being formed
  - Increased acid dew point temperature

# Lab-scale experiments at Zaragoza Univ.



# Kinetic modelling

- **Chemkin/mechanism**
  - Plug flow
  - Detailed gas-phase chemistry kinetics
  - S-chemistry during fuel oxidation in $CO_2/N_2$ atmopsheres
  - Hindiyarti, Glarborg and Marshall, 2007 and Gimenez-Lopez et al., 2011

# Key reactions in kinetic mechanism

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$$SO_2 + O\ (+M) \rightleftharpoons SO_3\ (+M) \quad (1)$$

$$SO_3 + H \rightleftharpoons SO_2 + OH \quad (2)$$

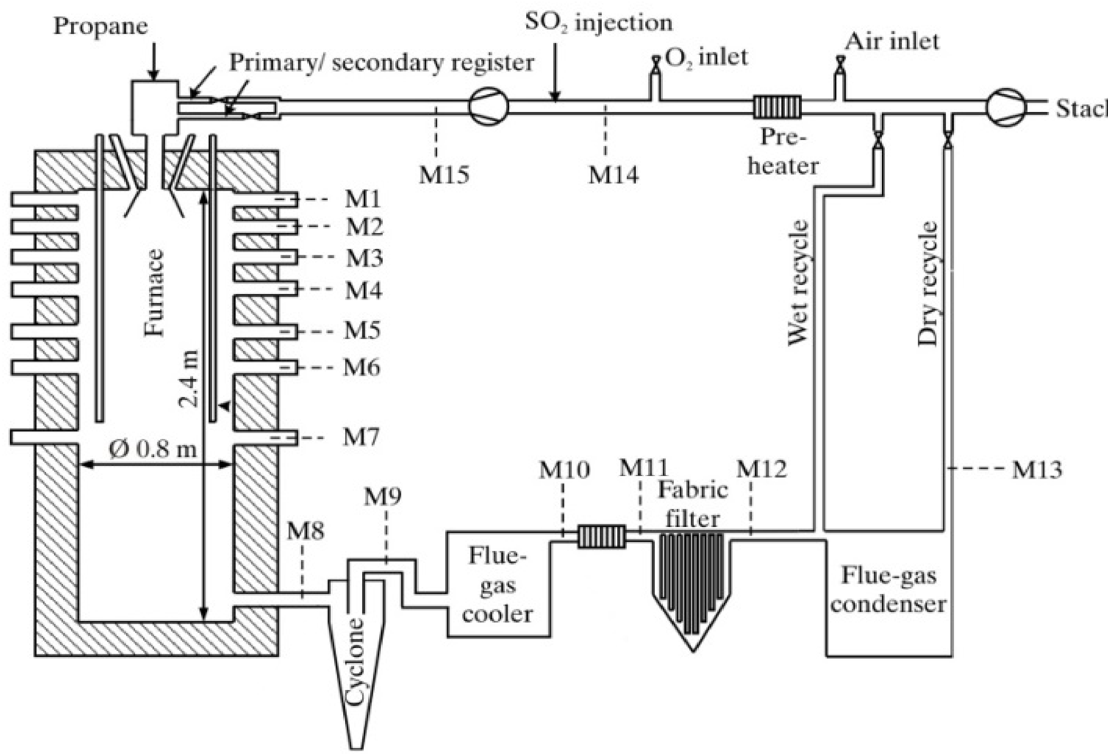
$$SO_2 + OH\ (+M) \rightleftharpoons HOSO_2\ (+M) \quad (3)$$

$$HOSO_2 + O_2 \rightleftharpoons SO_3 + HO_2 \quad (4)$$

# 100 kW propane experiments at Chalmers Univ.

## Propane

- $SO_2$-injection
- $SO_3$-measurements
- Controlled condensation
- Air-fuel and oxy-fuel

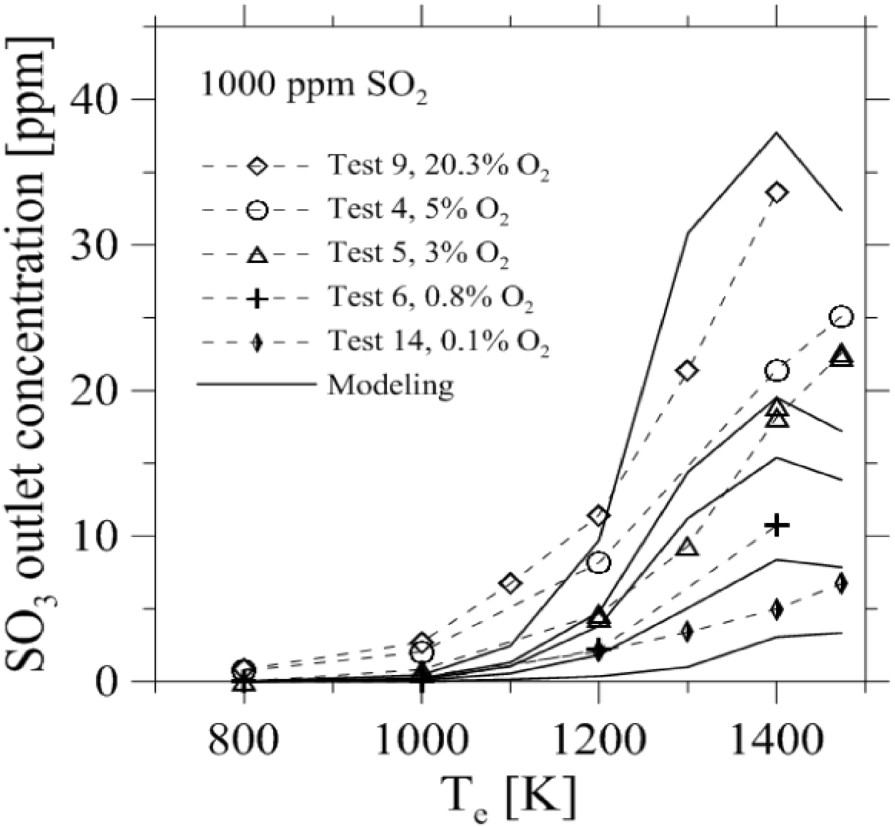


# Post flame $SO_3$ formation

Influence of temperature & gas composition: $O_2$, temperature, $SO_2$, $CO_2$, CO and Oxy vs. Air-fuel

# Lab-scale experiments: influence of $O_2$

- $SO_2$: 1000 ppm
- $N_2$-base
- $O_2$: 0.1-20.3%
- $T_e$: 800-1500 K



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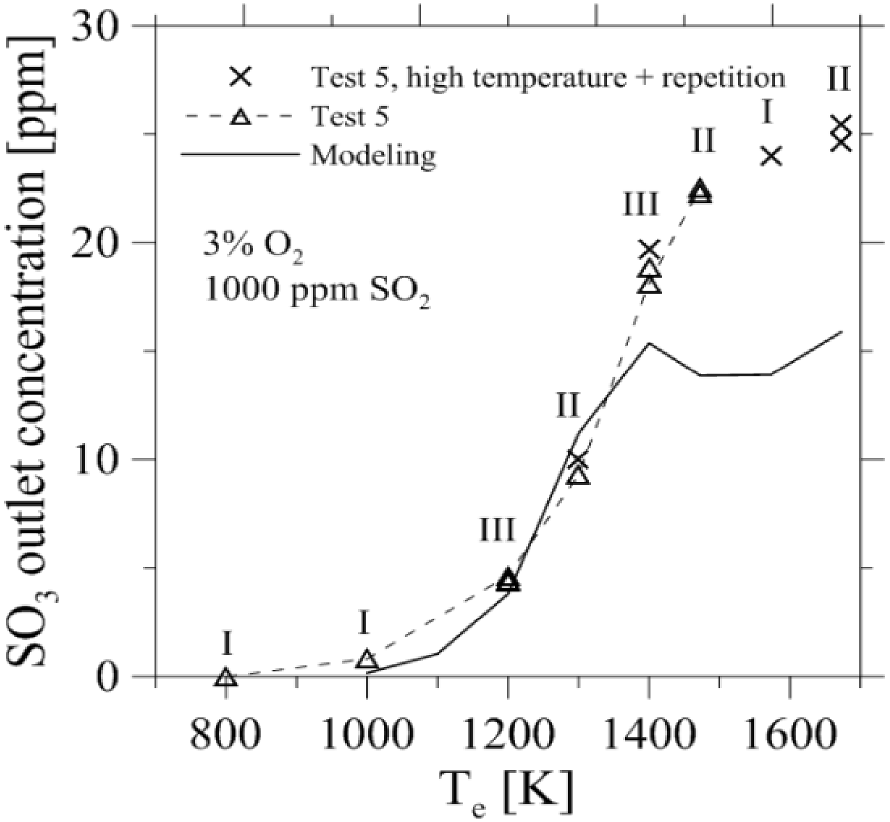
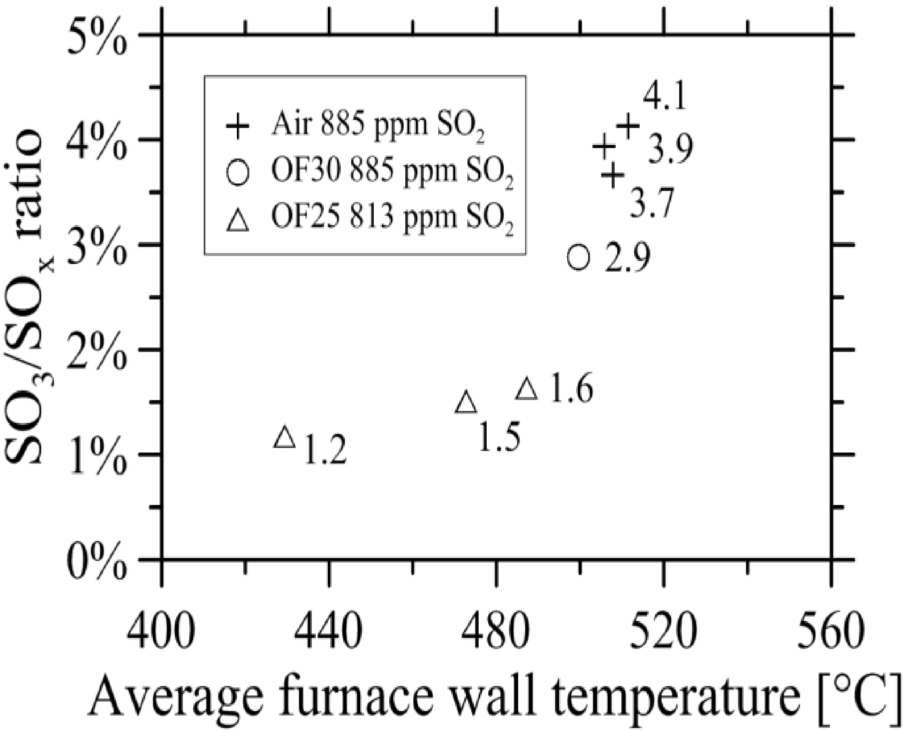
# Lab-scale experiments: influence of temperature

- $SO_2$: 1000 ppm
- $O_2$: 3%
- $N_2$-base
- $H_2O$: 1.1%



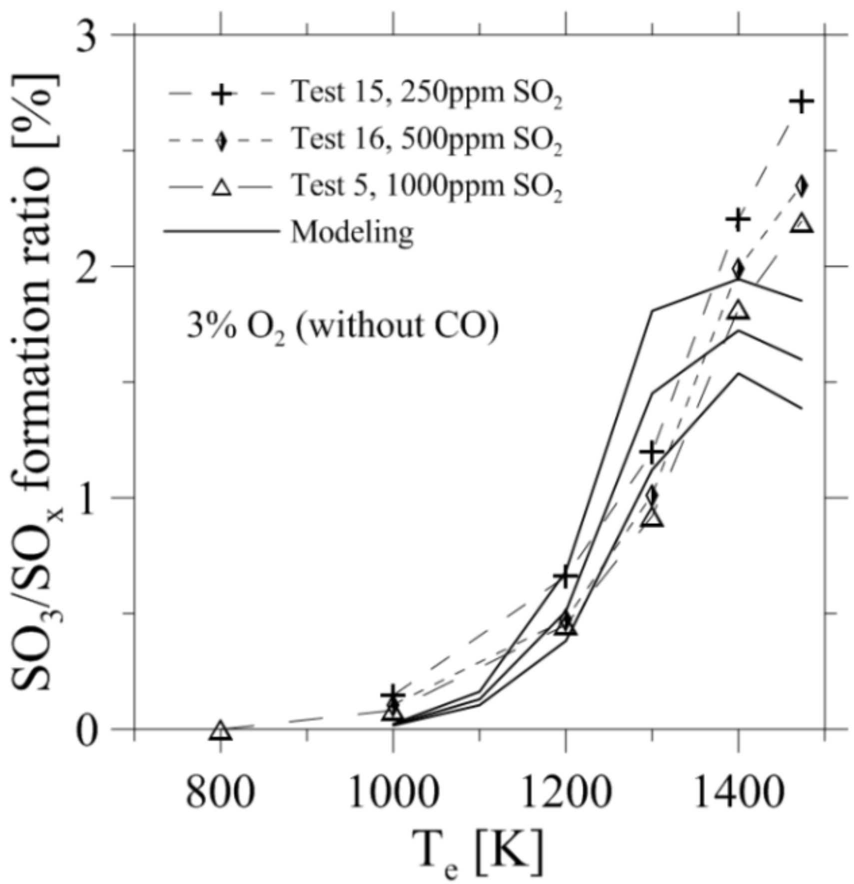
# 100 kW experiments: influence of temperature

- Temperature
- Air-fuel
- Oxy-fuel
  - OF 30
  - OF 25



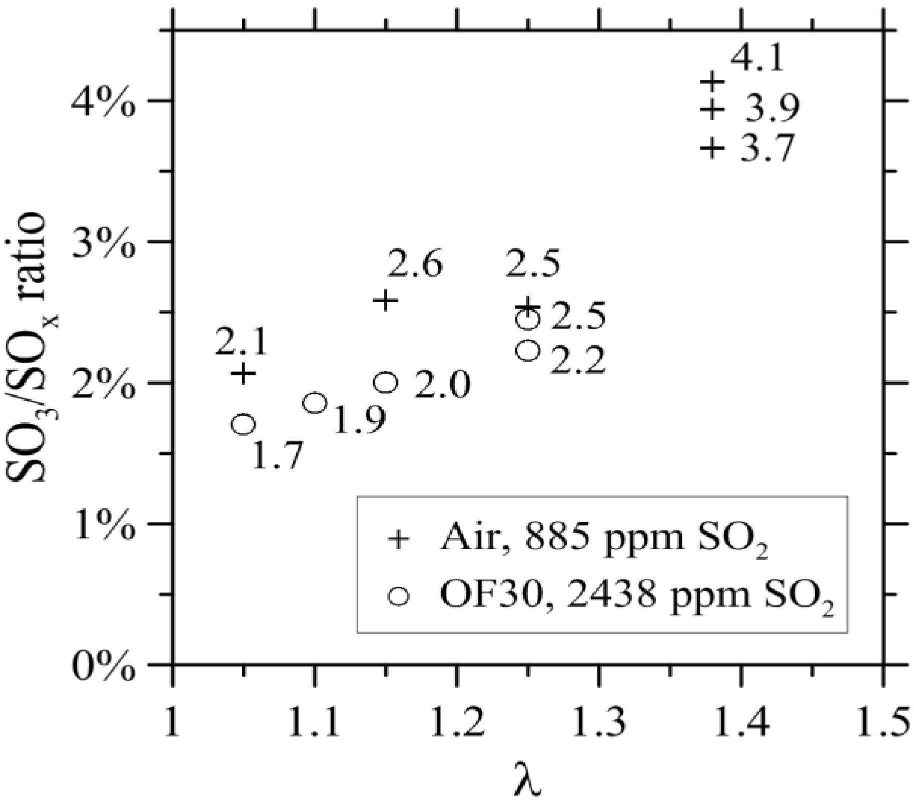
# Lab-scale experiments: influence of $SO_2$

- $N_2$ atmospheres
- 3 vol% $O_2$
- 250, 500, 1000 ppm $SO_2$



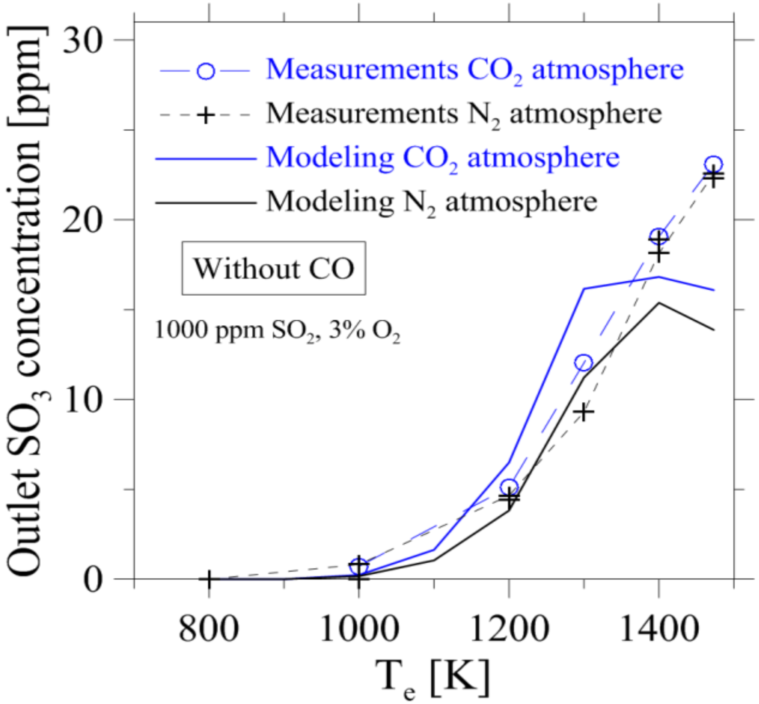
# 100 kW experiments: oxy-fuel vs air

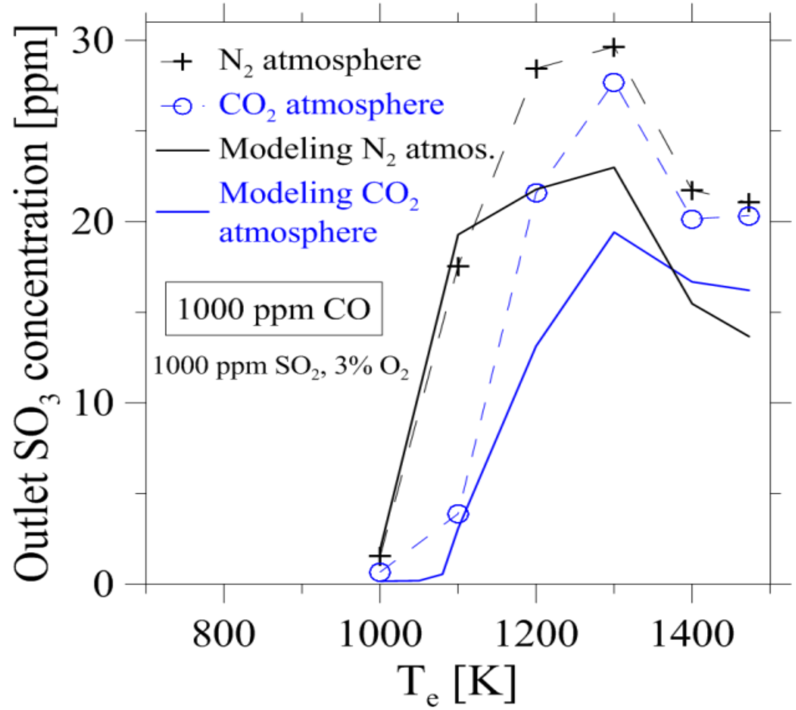
- Air vs. OF30
- $SO_2$
- Oxygen/fuel ratio
- $CO_2/N_2$-base



# Lab-scale experiments: influence of $CO_2$ and CO

- $CO_2$ or $N_2$; CO: 0 or 1000 ppm; $SO_2$: 1000 ppm; $O_2$: 3%; $N_2$-base



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# Conclusions

| | |
|---|---|
| **Increase in** $O_2$ concentration<br>**Increase in** $SO_2$ concentration | **Increase in** $SO_3$ concentration<br>**Increase in** $SO_3$ concentration |
| Presence of **CO or** $CH_4$ concentrations | Strong **increase in** $SO_3$ formation |
| **Increase in** $H_2O$ **concentration** | **Increase in** $SO_3$ formation in absence of CO<br>Decreases $SO_3$ formation during CO oxidation |
| **Increase in** $CO_2$ concentration | Slight **increase in** $SO_3$ formation **in absence of CO**<br>**Decreases** $SO_3$ formation **during CO conversion** |
| **Availability of NO** | **Can increase** $SO_3$ formation due to its influence on the radical pool |

# Conclusions

| | |
|---|---|
| **Absence of airborne $N_2$** | **Increase in $SO_2$** concentration |
| **Change in flue gas residence time** (depending on FGR ratio) | **Longer residence time: increase in $SO_3$** concentration |
| **Change from dry to wet FGR** | Increase in $H_2O$ concentration **favors $SO_3$** formation, but the **decrease in $SO_2$ concentration will counteract** |
| **Change in temperature conditions** (mainly dependent upon the $O_2$ concentration in the oxidizer) | Influences the **release of sulfur from the coal** and the **capture of $SO_x$ by ash-**forming matter<br>**Influences** the level of **$SO_3$ formation**[9,25] |

# Acknowledgement

Our colleagues at the University of Zaragoza

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