

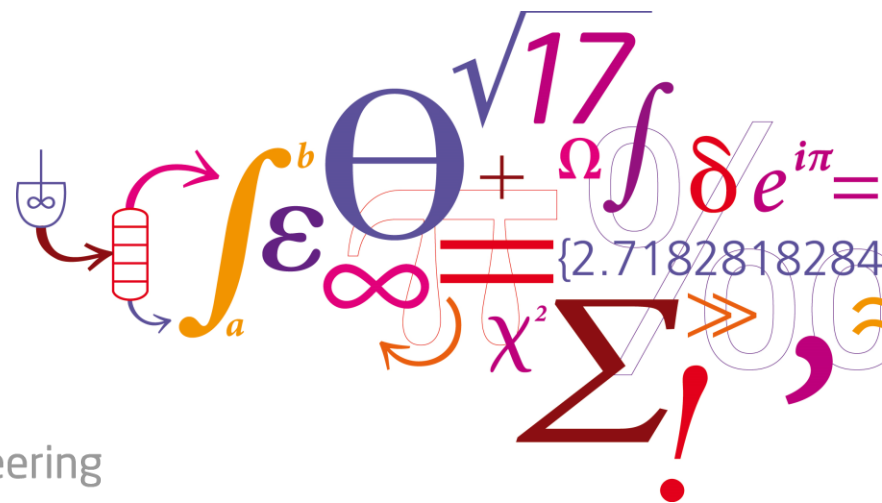
CPFD Simulation of a Full-Scale Calciner Operating with Refuse Derived Fuel



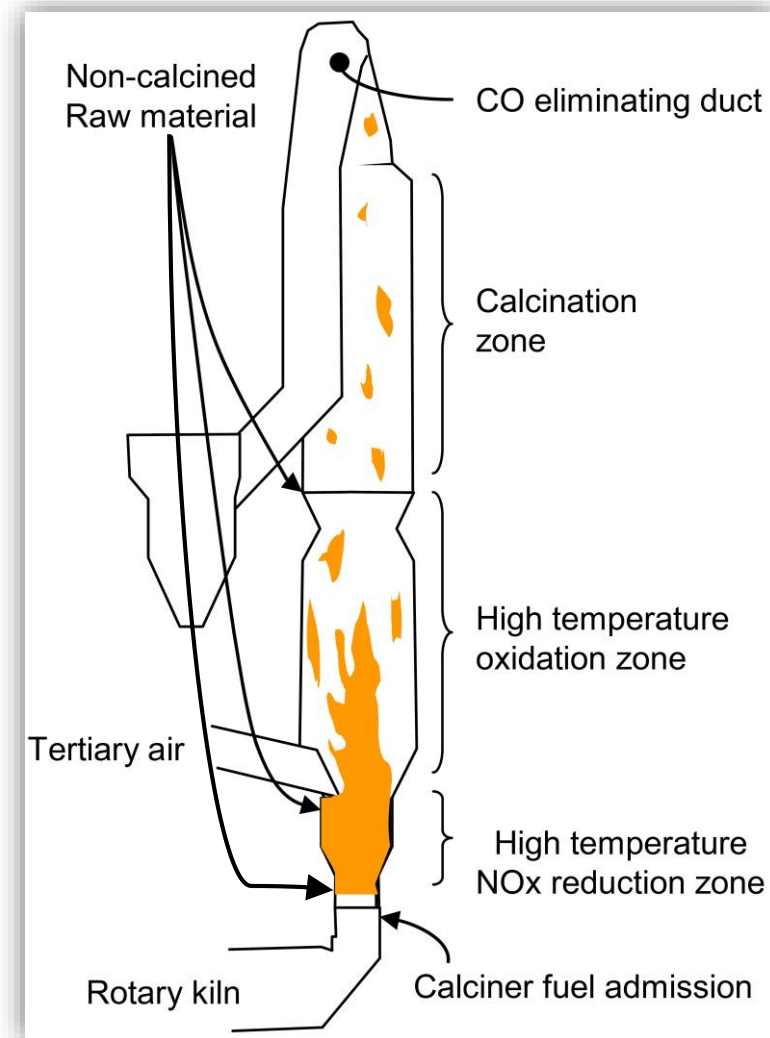
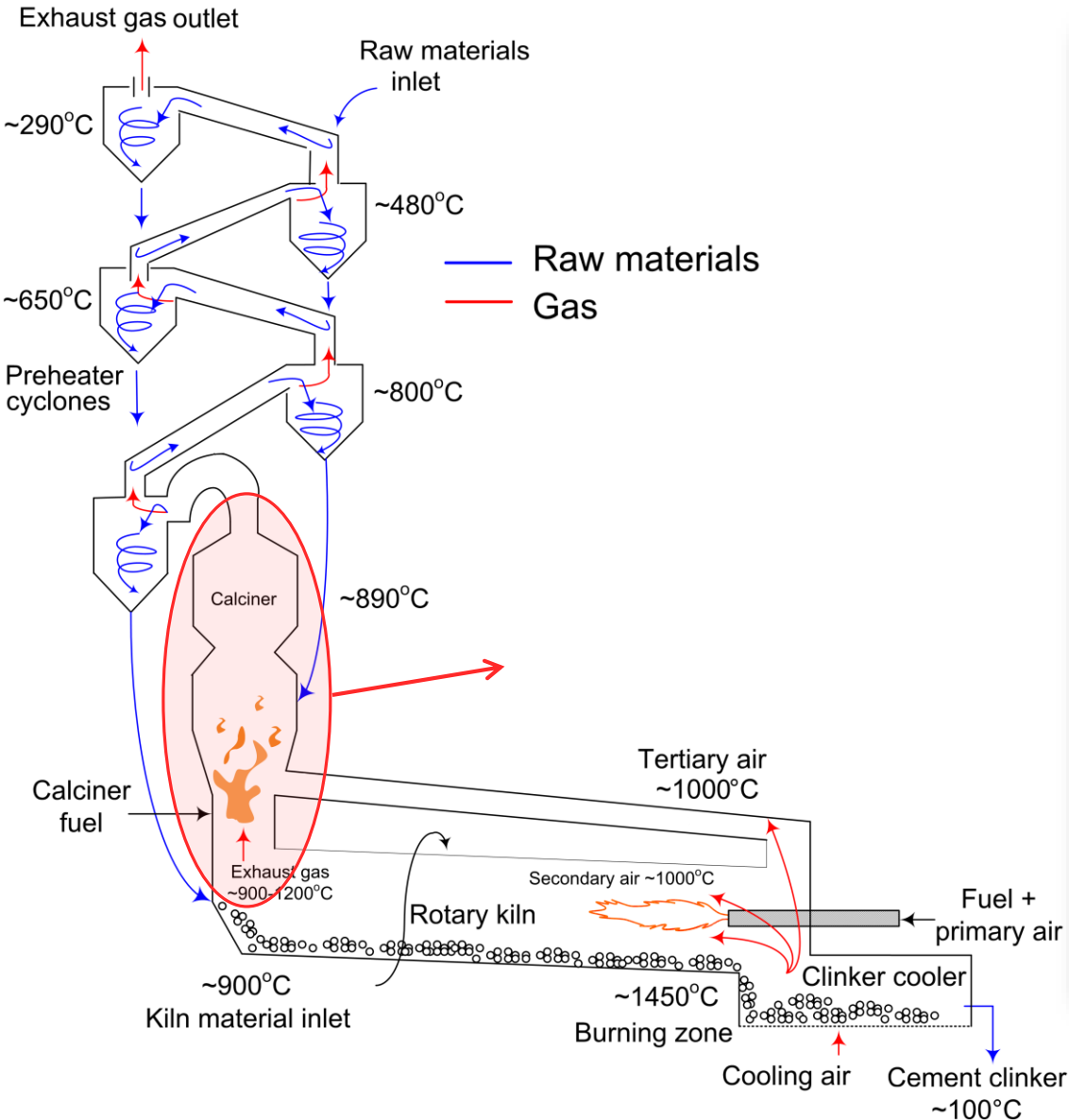
Mohammadhadi Nakhaei
Postdoc



DTU Chemical Engineering
Department of Chemical and Biochemical Engineering

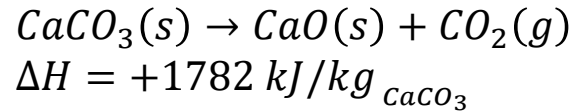


Background – *alternative fuels in cement calciner*



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Calcination



Fuel conversion

❖ Conventional fuels

✓ Oil ✓ Gas ✓ Coal ✓ Petcoke

❖ Alternative fuels

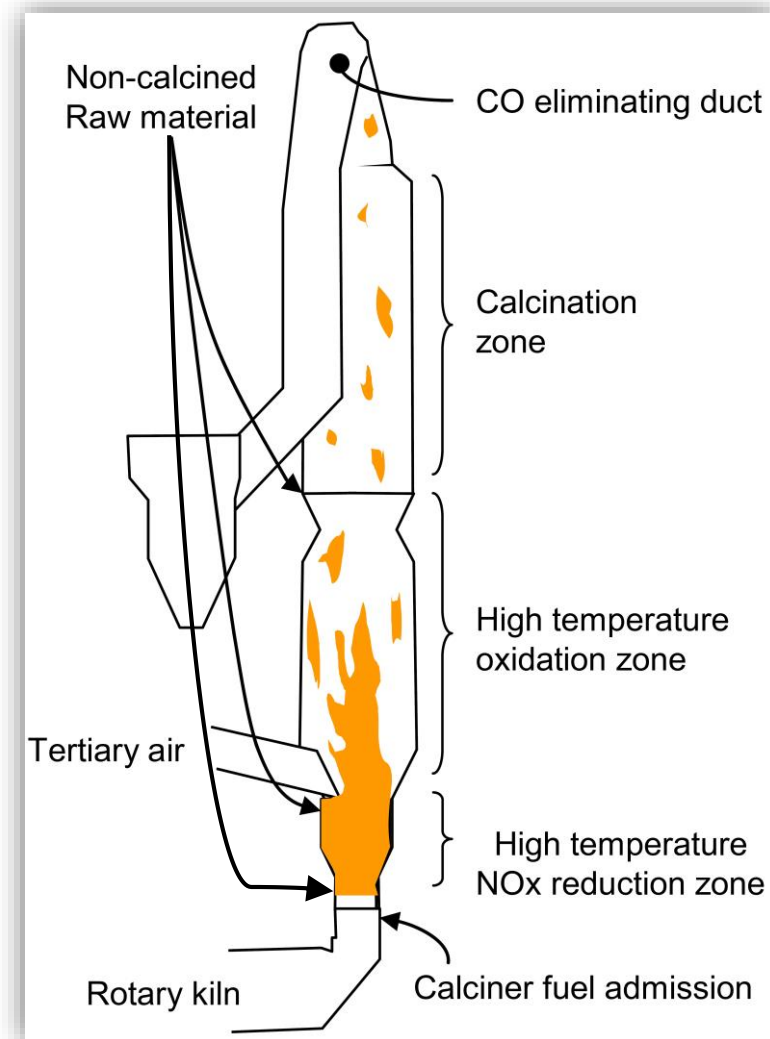
✓ Sewage sludge ✓ Meat and bone meal ✓ Car tires
✓ Solid recovered fuel (SRF)
✓ Refuse derived fuel (RDF)

Motivations

- Cheap/free alternative
- CO₂ emission reduction
- Waste disposal

Challenges

- Fuel burnout
- Change in emissions
- Stability of operation

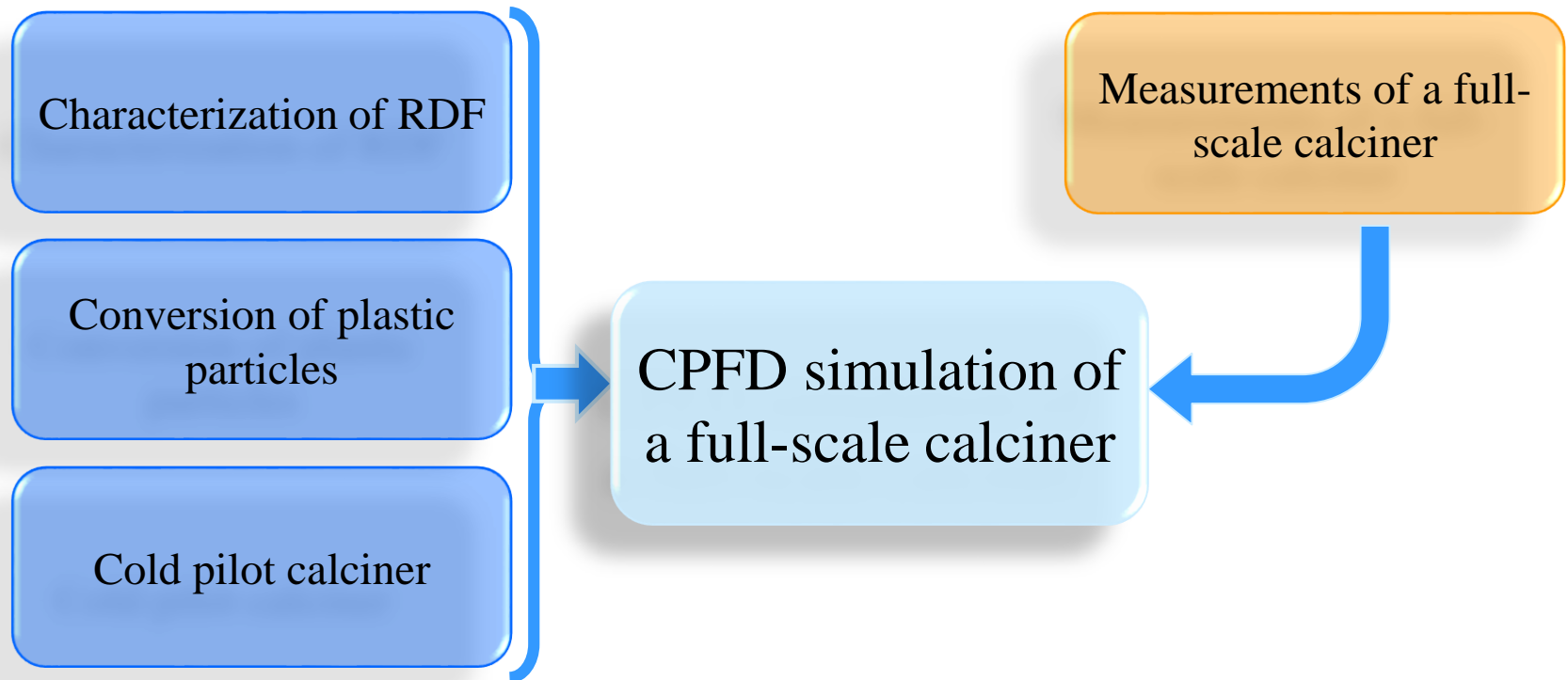


Overview of the study

❖ Objectives

- A reliable CPFD tool for simulation of RDF-fired calciners

❖ Content



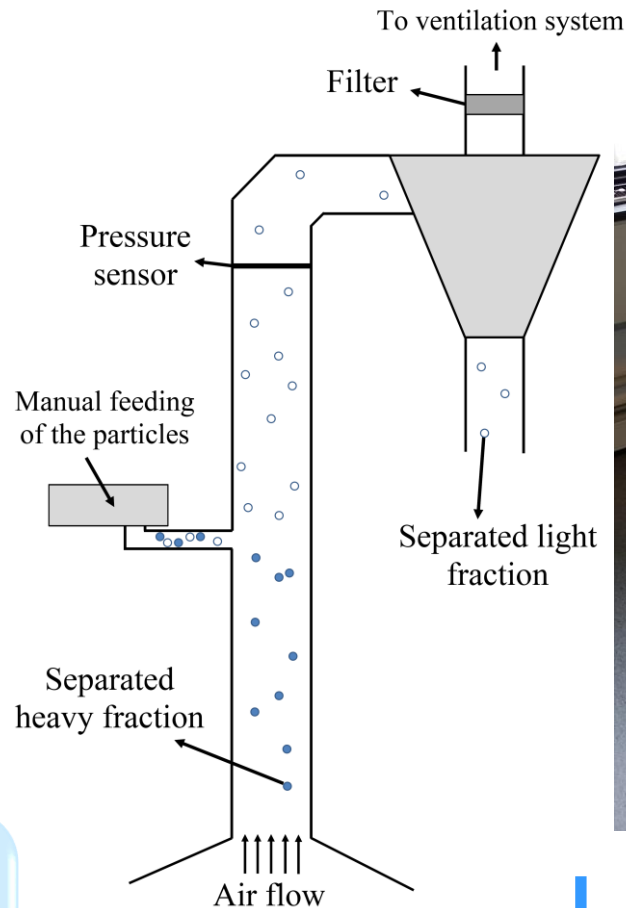
Characterization of RDF



M. Nakhaei et al., *Energy & Fuels*, 32 (2018), 7685-7700.

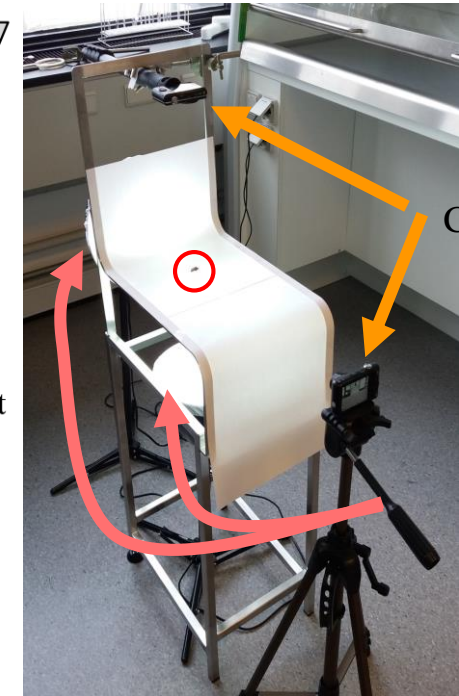
CPFD input

Particle size, shape, and material distribution + proper drag model



Wind sieve

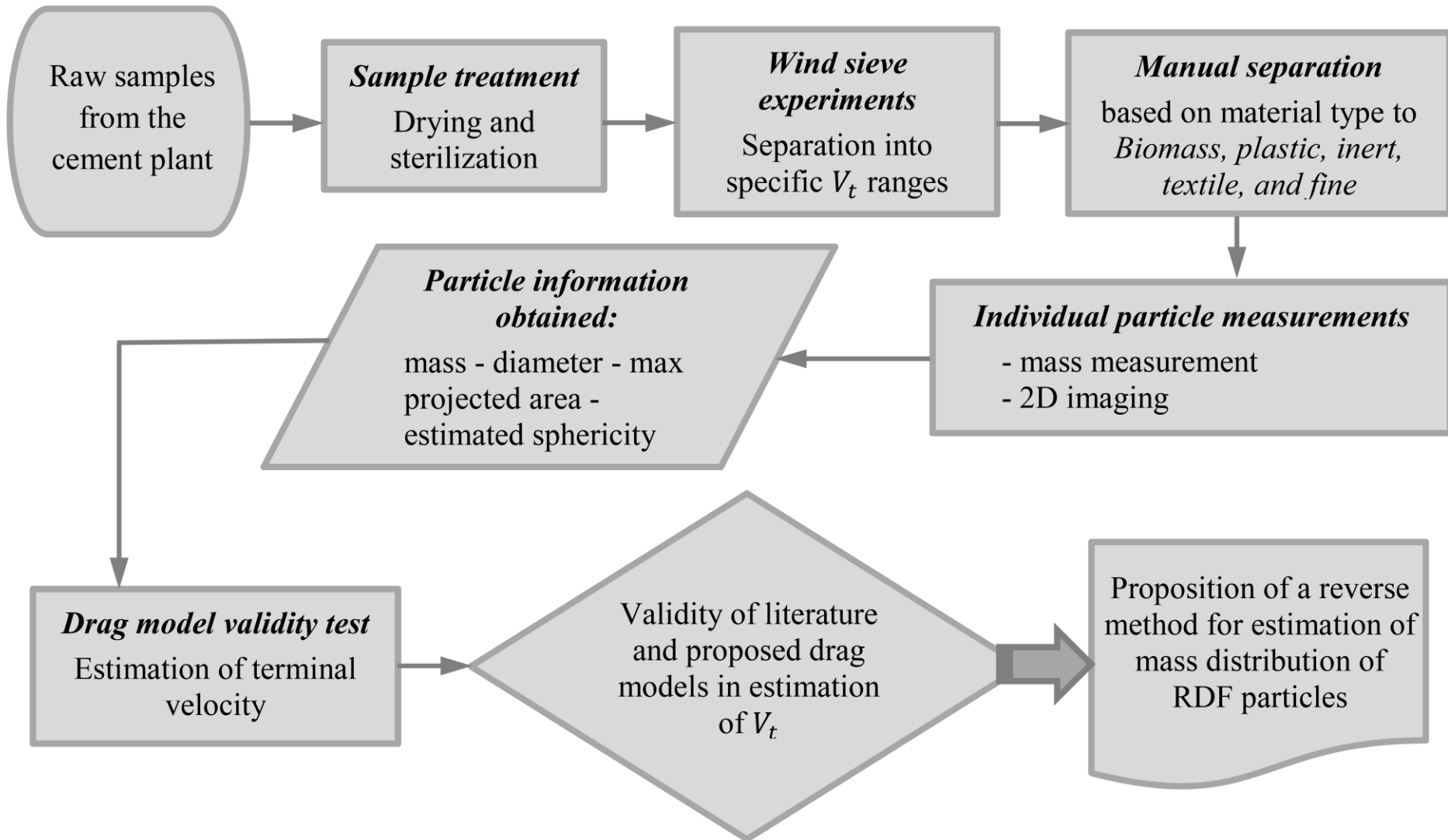
Particle categorization based on terminal velocity



Photographing Platform

Estimation of size and shape

Characterization of RDF – overall approach

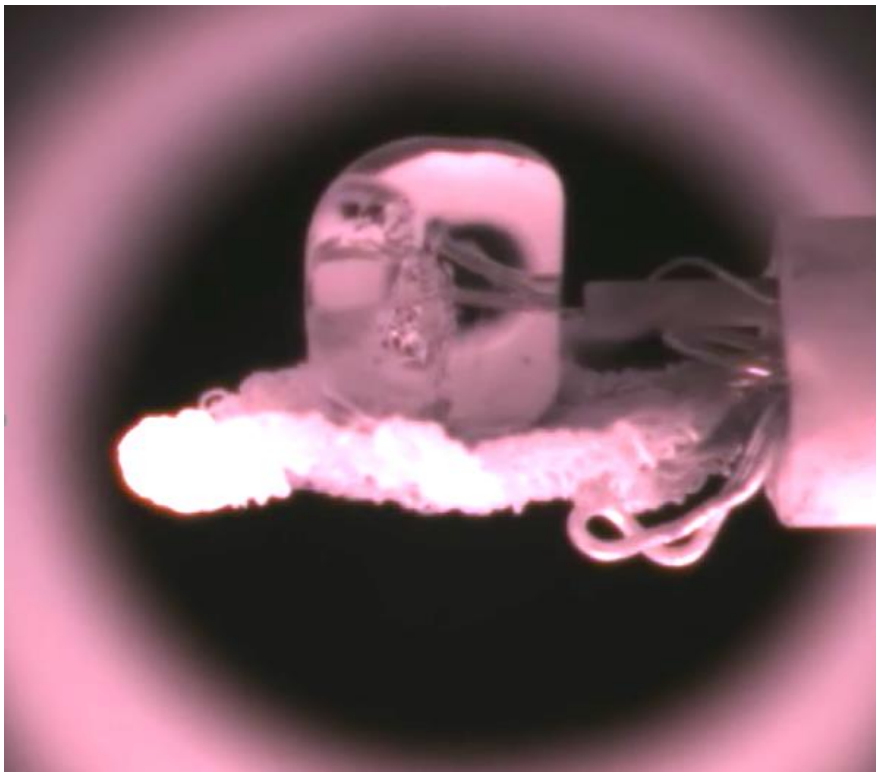


Conversion of plastic particles

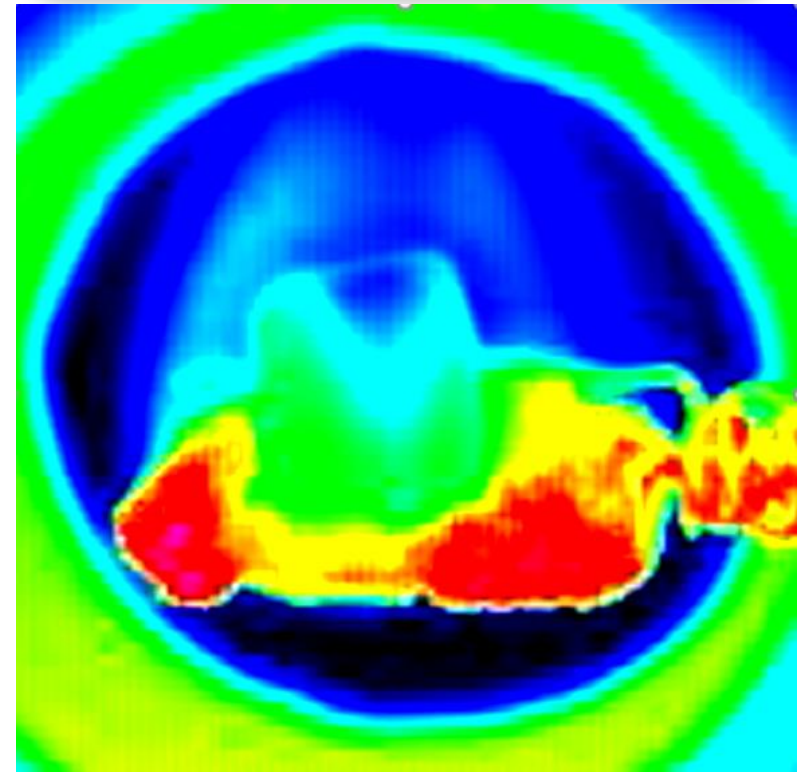
- ❑ Conversion of plastics and temperature measurements
- ❑ A 1-D mathematical model and validate

CPFD input

Simplified conversion model for plastics



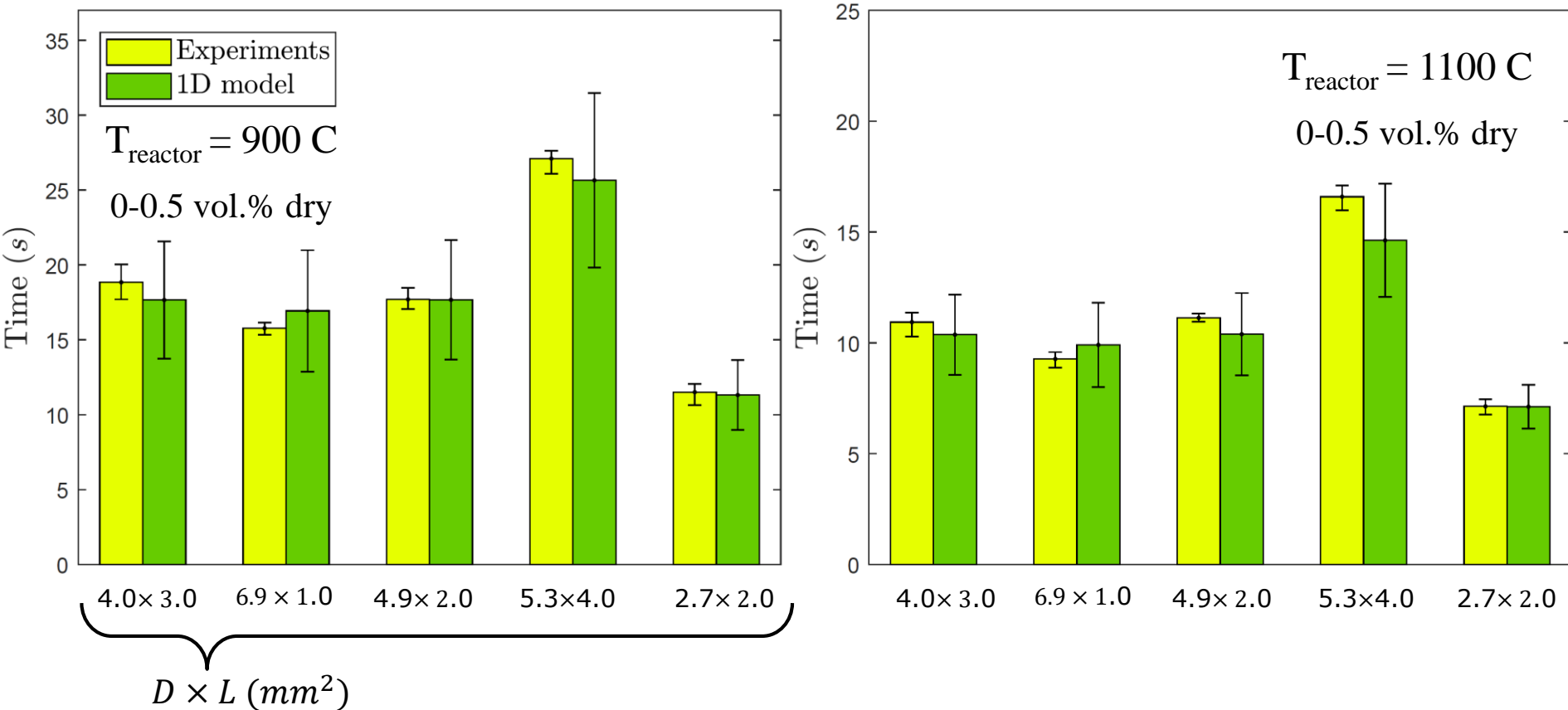
1100C and 0-0.5 vol.% dry O₂



900C and 0-0.5 vol.% dry O₂

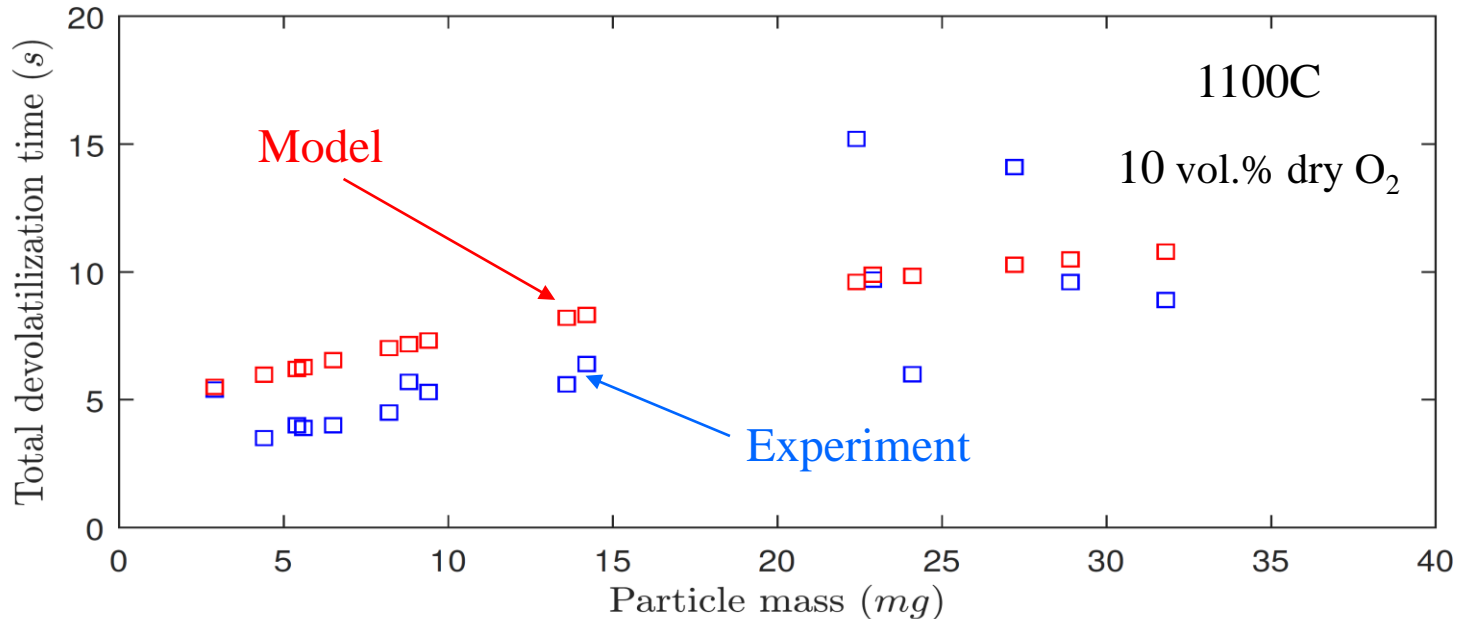
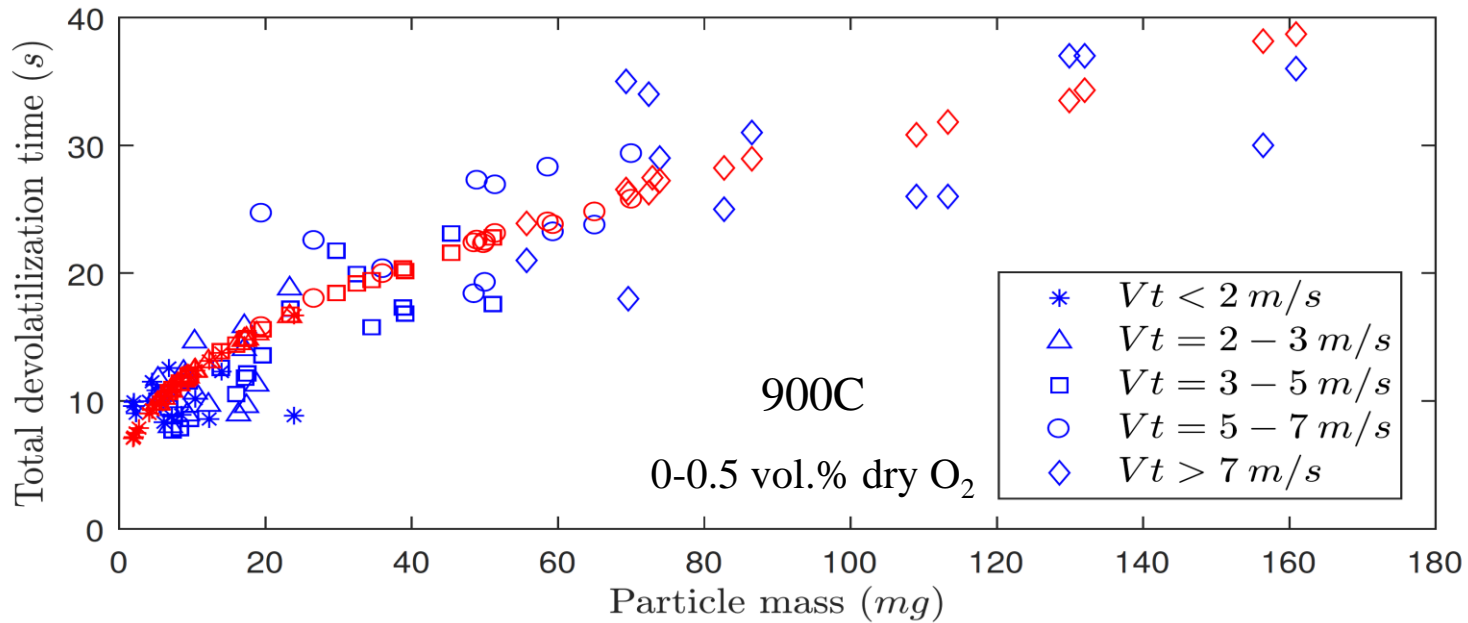
Conversion of plastic particles – *model results*

Man-made HDPE particles (cylindrical)



Conversion of plastic particles – *model results*

*Plastics in
RDF*

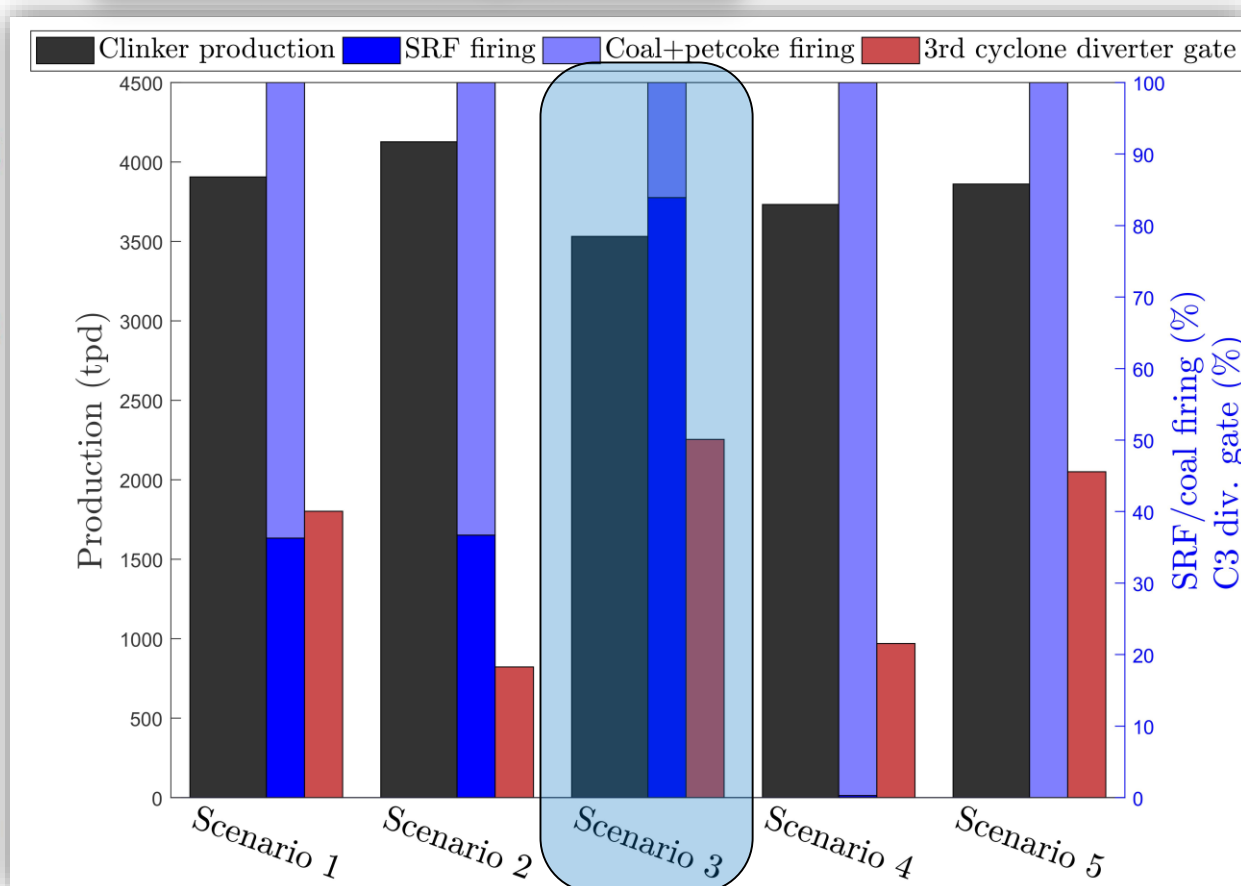
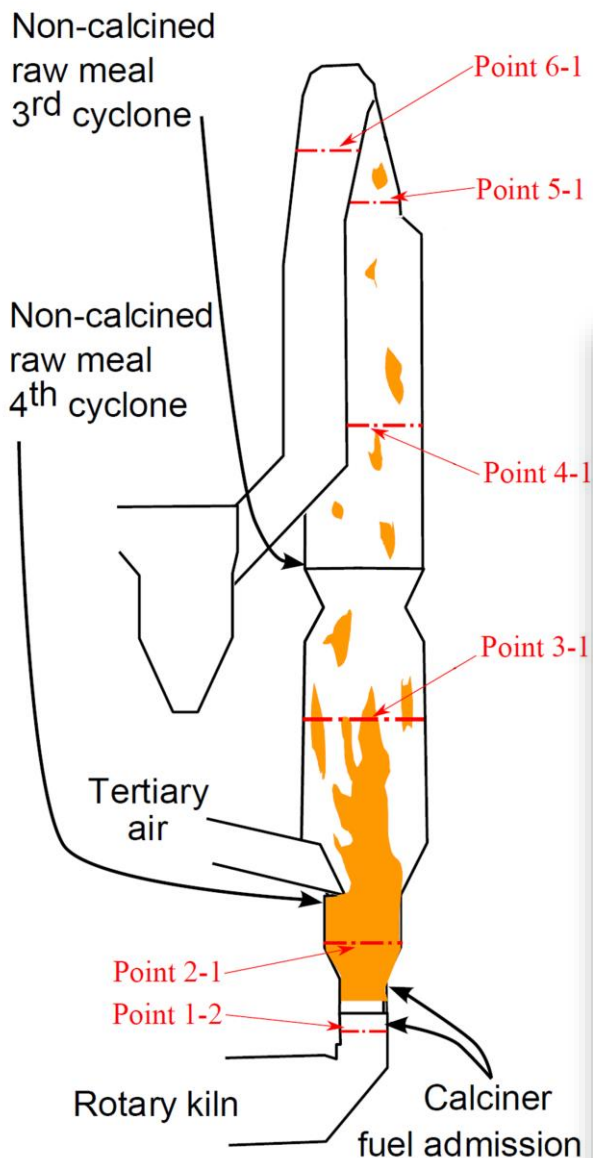


Measurements of a full-scale calciner

□ More knowledge about the calciner performance

CPFD input

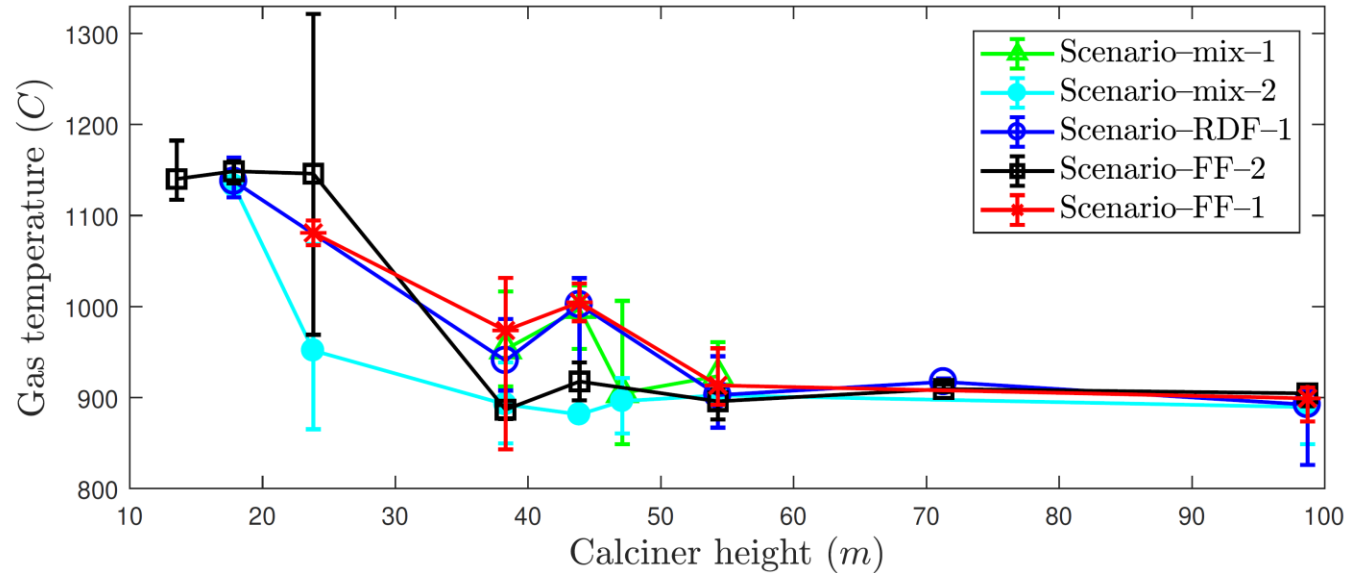
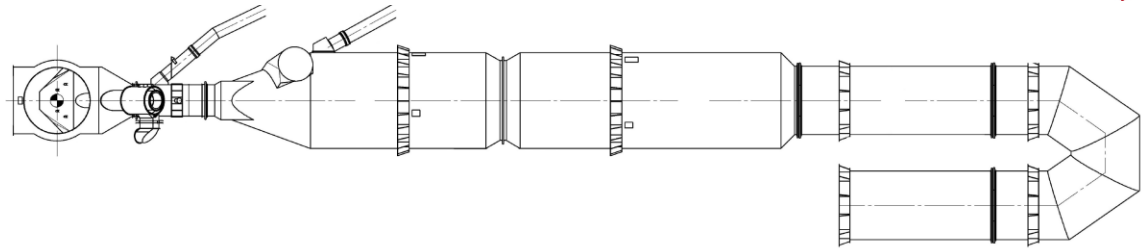
Data for comparison



Measurements of a full-scale calciner – *results*

Measured parameters

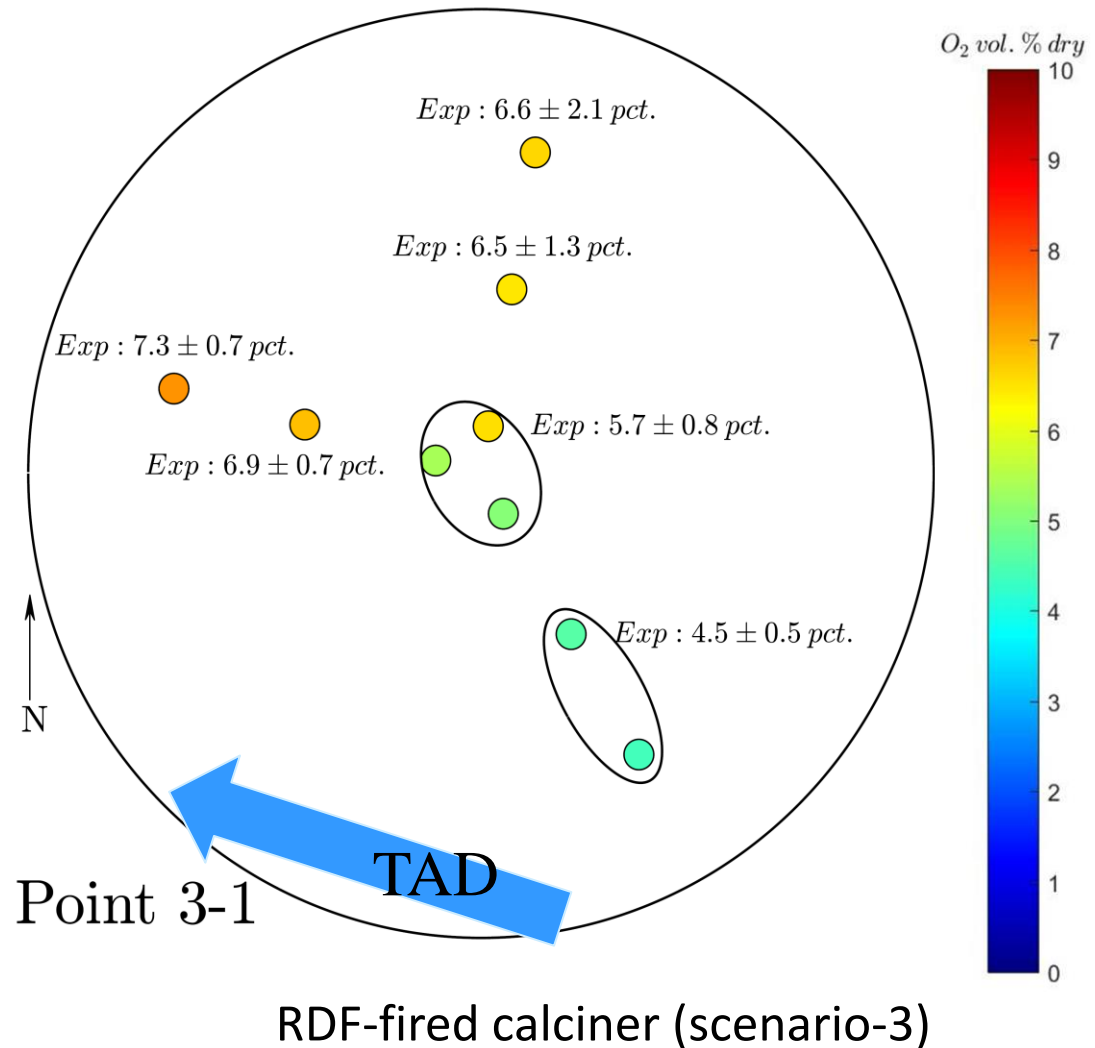
- ❖ Gas temperature
- ❖ Gas species concentration
 - O_2
 - CO_2
 - CO
 - NO
- ❖ Fuel burnout (FFG)
- ❖ Calcination degree (CF)



Measurements of a full-scale calciner – *results*

Measured parameters

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- ❖ Gas species concentration
 - O_2
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CPFD simulation of a full-scale calciner – *simulation setup*

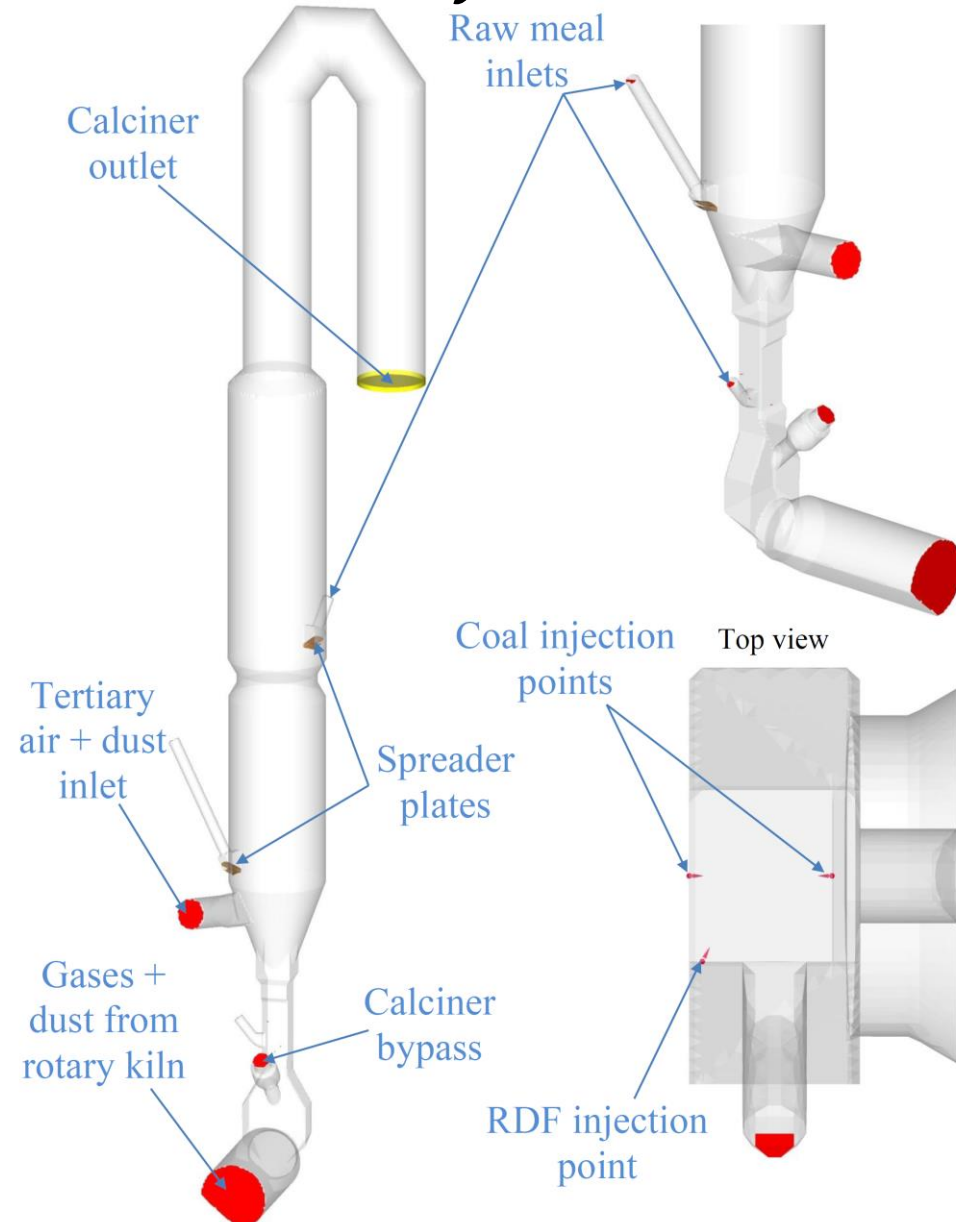
Chemical reactions

❖ *Heterogeneous*

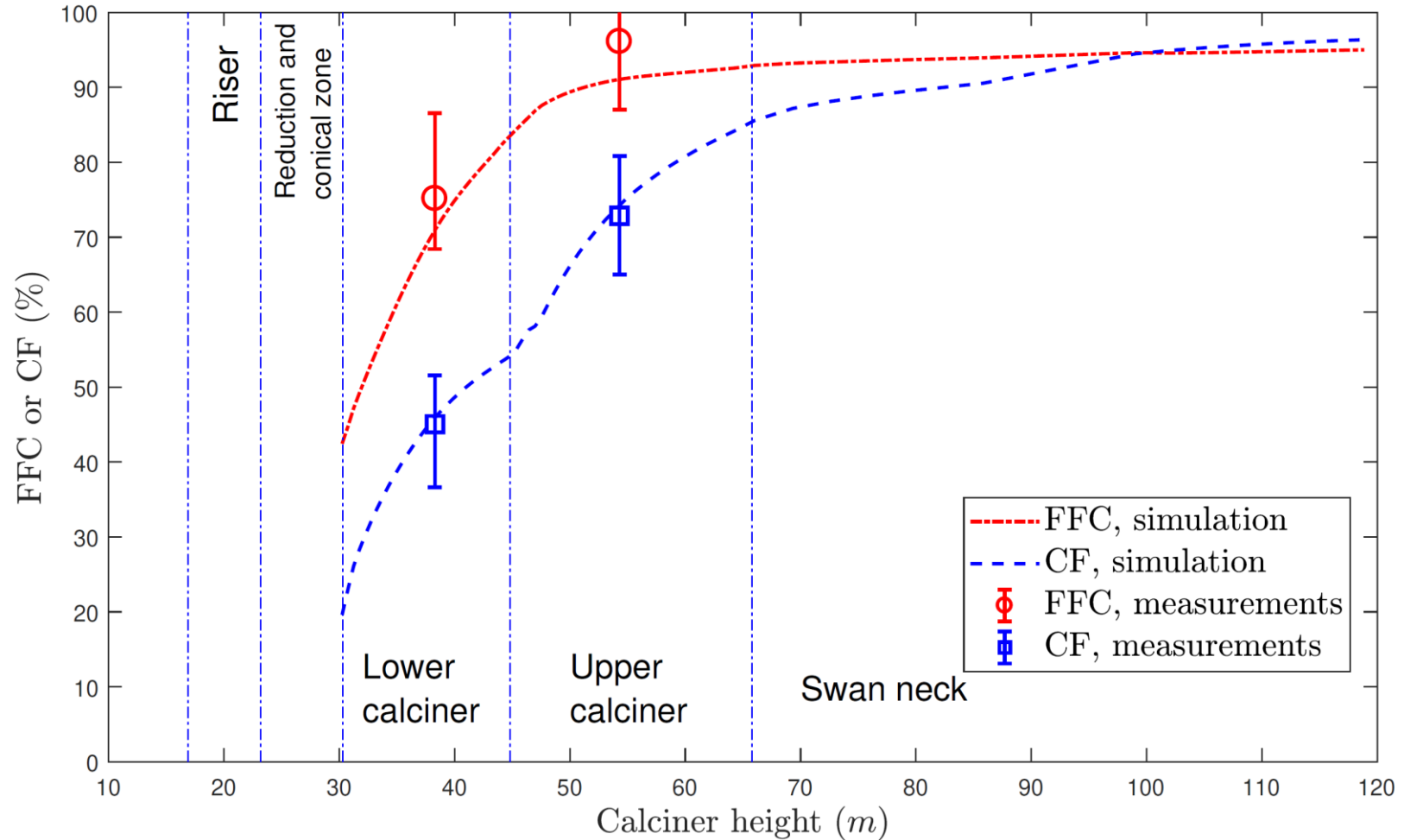
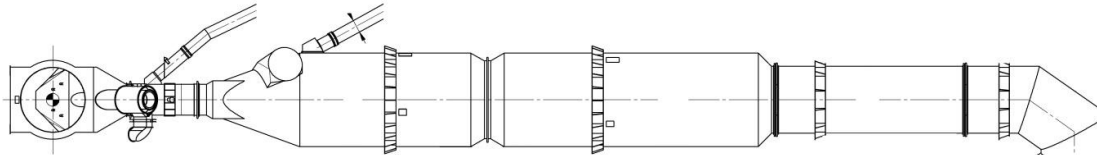
- Calcination of raw meal particles
- Oxidation of solid fuel particles
 - ✓ *Petcoke*
 - ✓ *RDF – plastic*
 - ✓ *RDF – biomass*
 - ✓ *RDF – inert*

❖ *Homogeneous*

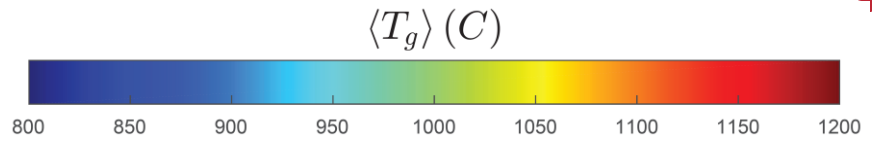
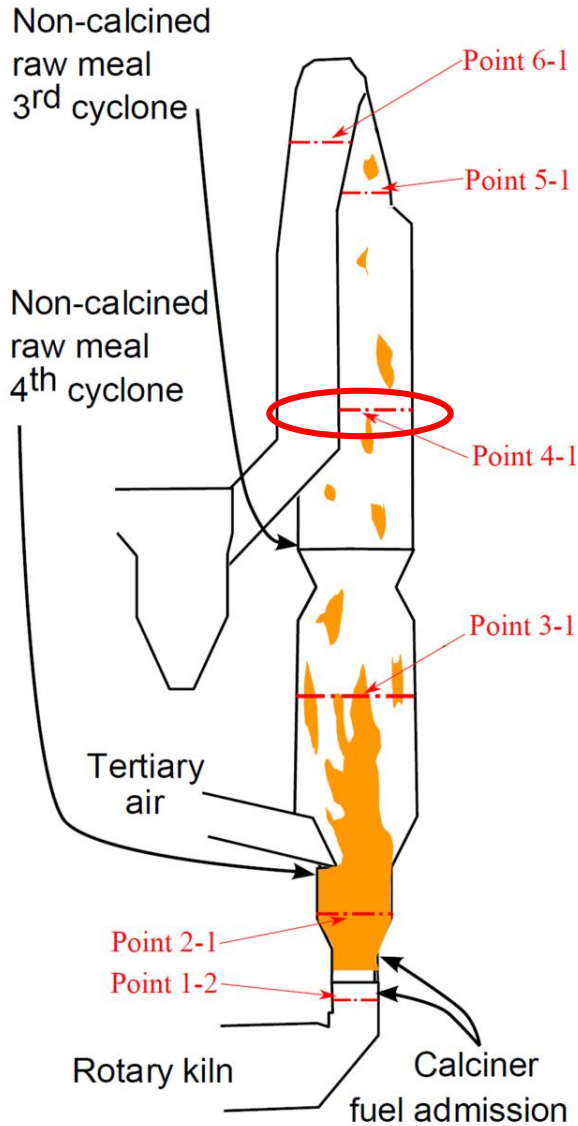
- CH_4 and CO oxidation



CPFD simulation of a full-scale calciner – *results*



CPFD simulation of a full-scale calciner – results

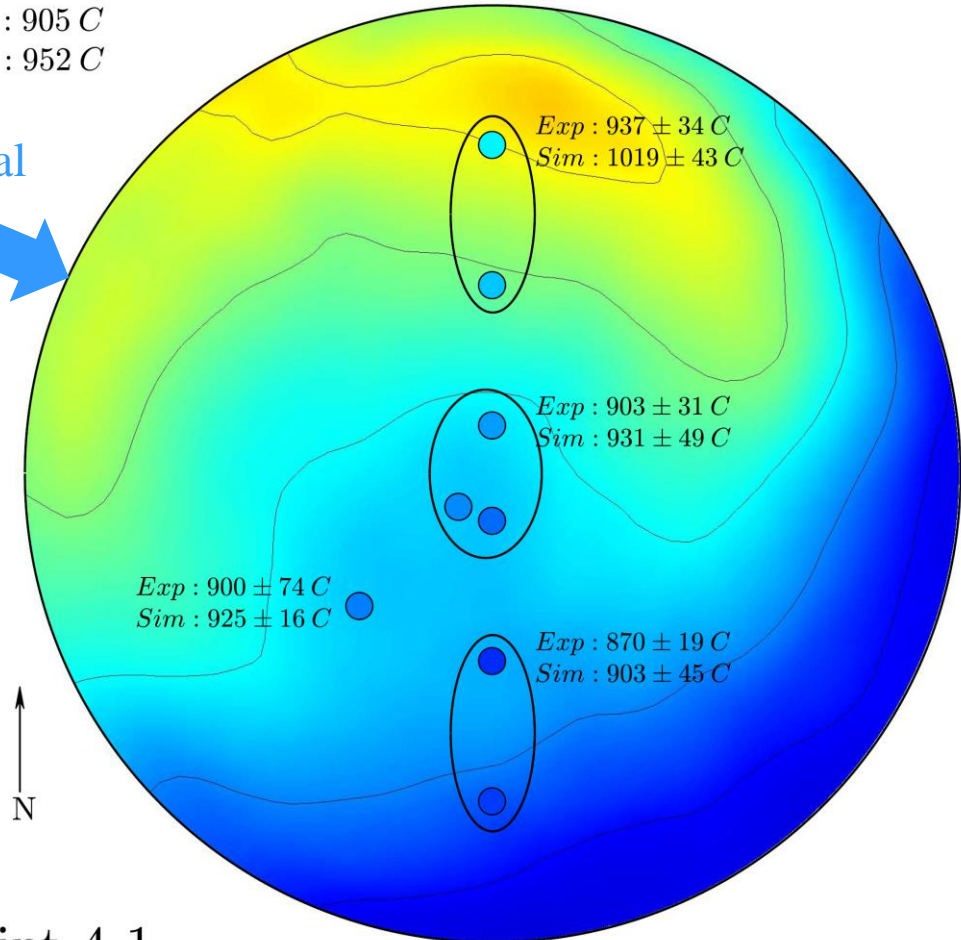


Area-averaged values:

Exp : 905 C

Sim : 952 C

Raw meal inlet



Point 4-1

❖ *Summary*

- Establishment of a method for physical and aerodynamic characterization of RDF particles
- Development of a simplified model for conversion of plastic particles to be used in CPFD calculations
- Carrying out full-scale measurements of an RDF-fired calciner
- CPFD simulations of full-scale RDF-fired calciner
 - ✓ *The overall trends are well-predicted*
 - ✓ *Still room for improvements (gas temperature)*

❖ *Future work*

- Addition of NO_x reaction kinetics to the CPFD model
- Try out the model for other types of calciner systems

Thank you for your attention

