



**Industrial-scale validation of a CFD simulation in
conjunction with a fuel-bed model**

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Contents

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- **Validation measurements**
- **Results / discussion / validation**
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Motivation for modeling / simulation

- Customer requirements
- Part of contract
- State-of-the-art in combustion technology
- Process optimization for combustion technology
- Detailed investigations
- Solution to complex issues
- Trouble-shooting (corrosion, boiler etc.)

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Numeric modeling

Fuel-bed modeling

PROFILER II

- Transport / mixing
- Starting values
- Variation of constraints (underfire air flow etc.)

Computational Fluid Dynamics

FLUENT

- Velocity profiles
- Temperature profiles
- Concentration profiles (O₂, CO)



Description of thermal / reaction-kinetic processes

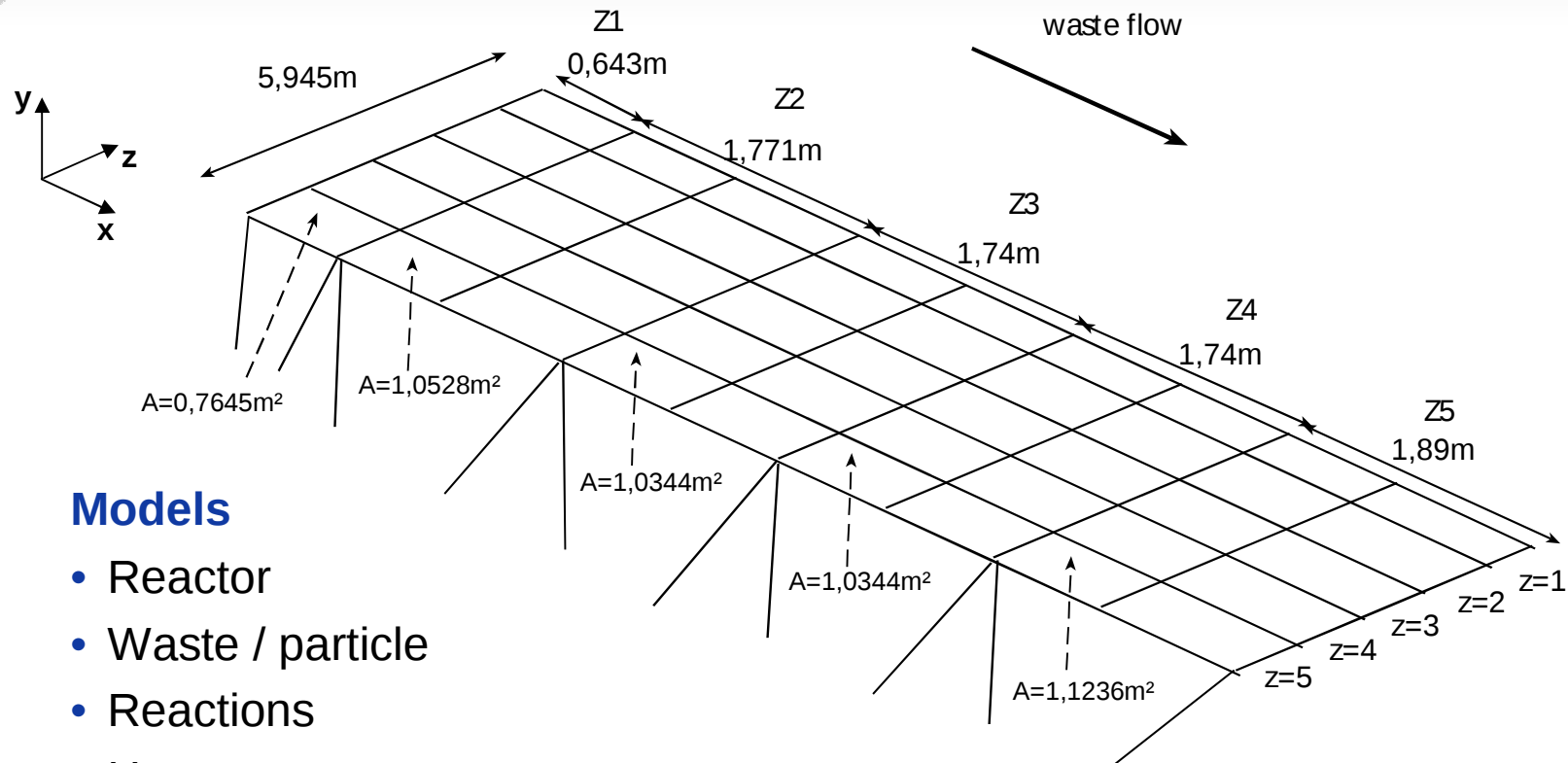
Validation and practical orientation imperative

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PROFILER II



Models

- Reactor
- Waste / particle
- Reactions
- Heat transport

Transfer to CFD model, per cell, direction normal to surface:
Gas concentrations, temperature, velocities, mass or volume flow

Re-transfer from CFD model, in stationary status:
radiation heat from combustion chamber onto waste bed for each cell q [W/m²]

Fuel bed 3 layers (y)

135 cells

Gas phase 10 cells

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Validation

- **Simulation of fuel bed**
using parameters of measurement campaign / radiation heat from combustion chamber onto fuel bed (FLUENT)
- **Comparison of simulation / measurements**
- **Adaption / optimization of model parameters**
- **Recalculation of fuel bed**



- **Comparison CFD simulation / measurements**
using starting values (PROFILER II)

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Validation measurements

IR camera

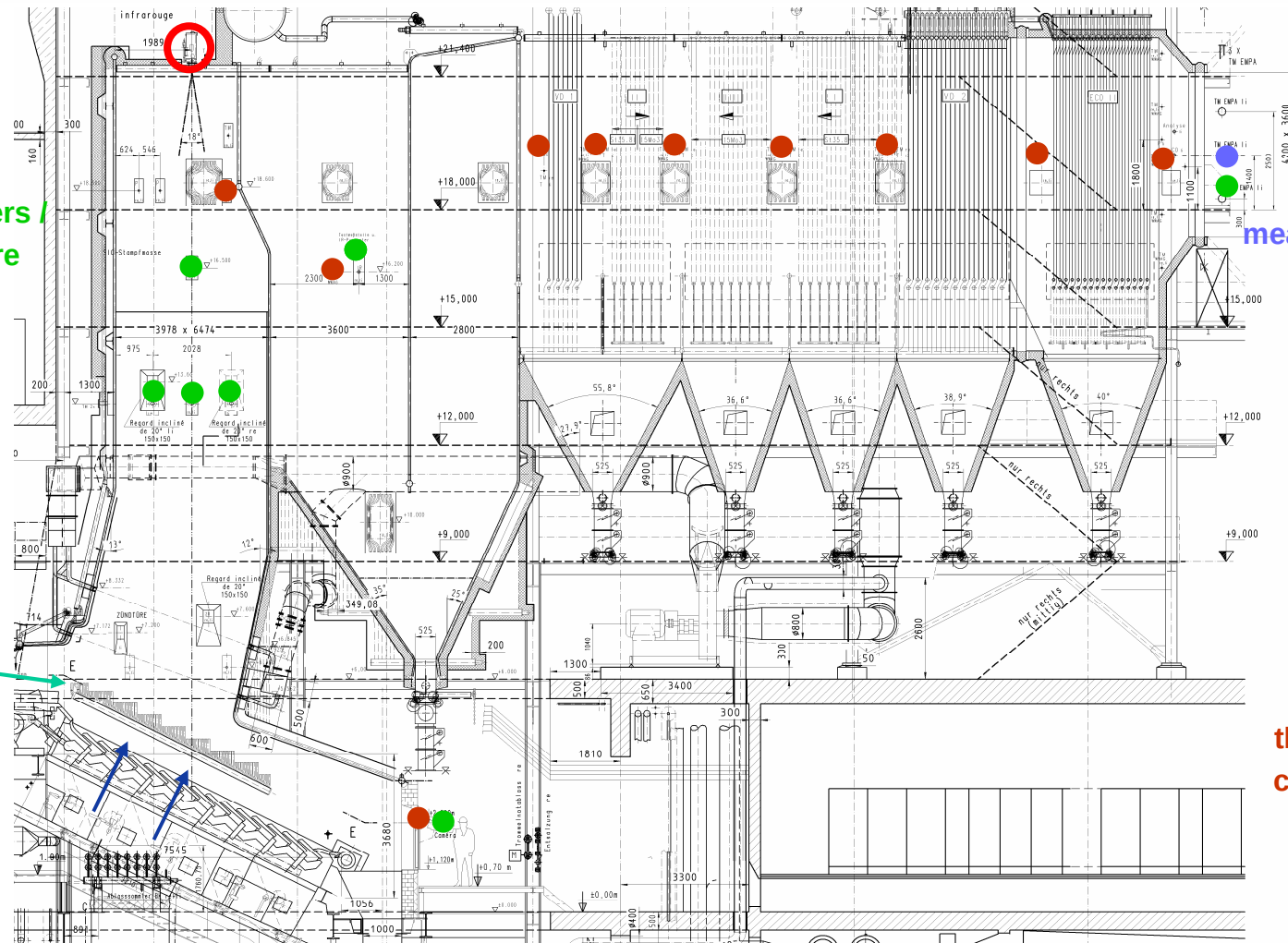
suction pyrometers /
high-temperature
anemometer

temperature
probes /
ball instrument

insertable
thermocouples

suction
measurements

thermo-
couples



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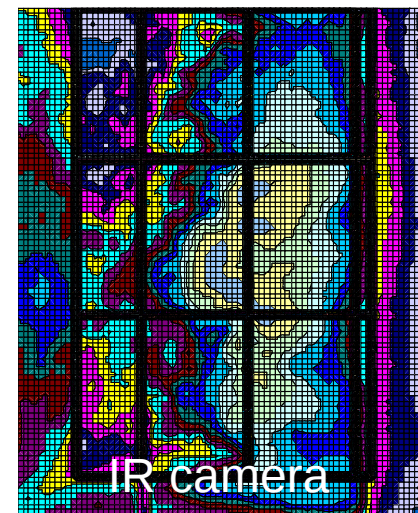
Validation measurements



High-temperature
anemometer



Suction pyrometer



IR camera



Ball instrument



Insertable
thermocouples



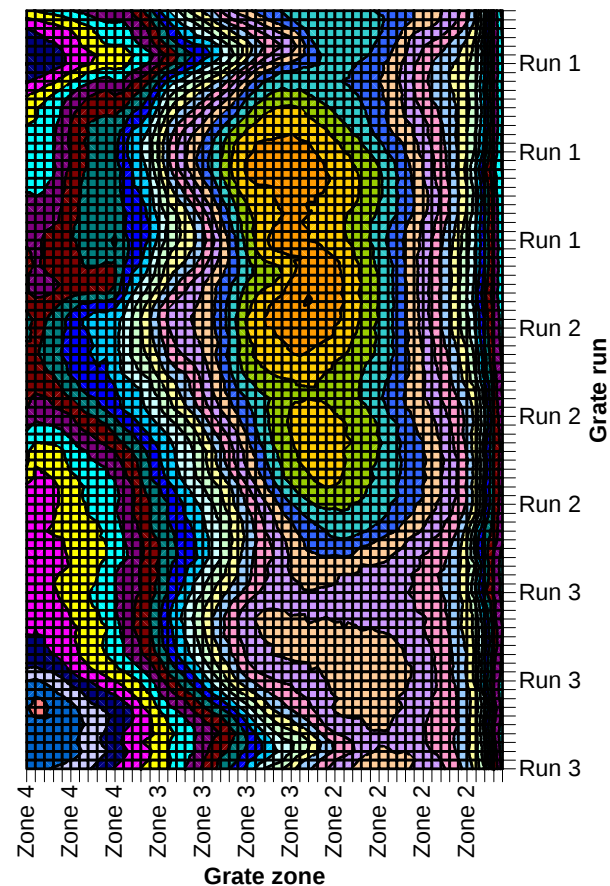
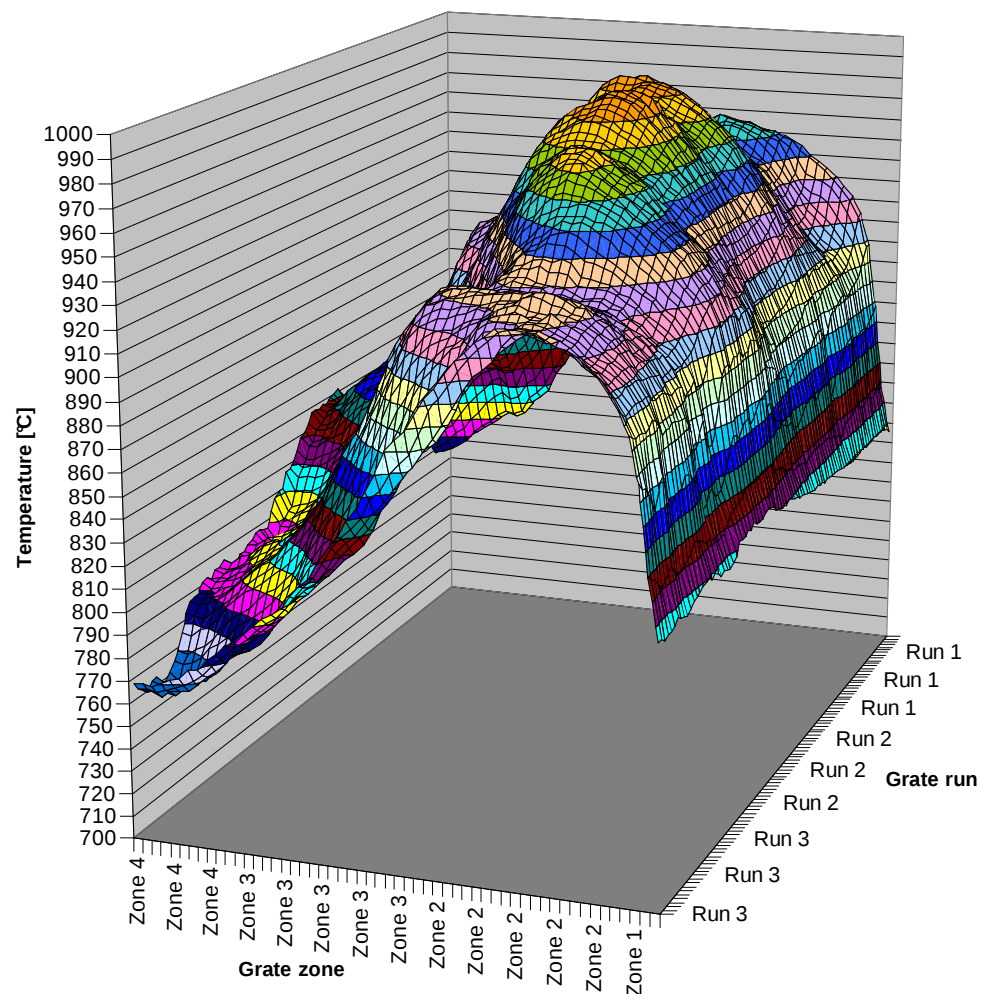
Temperature probes

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IR camera

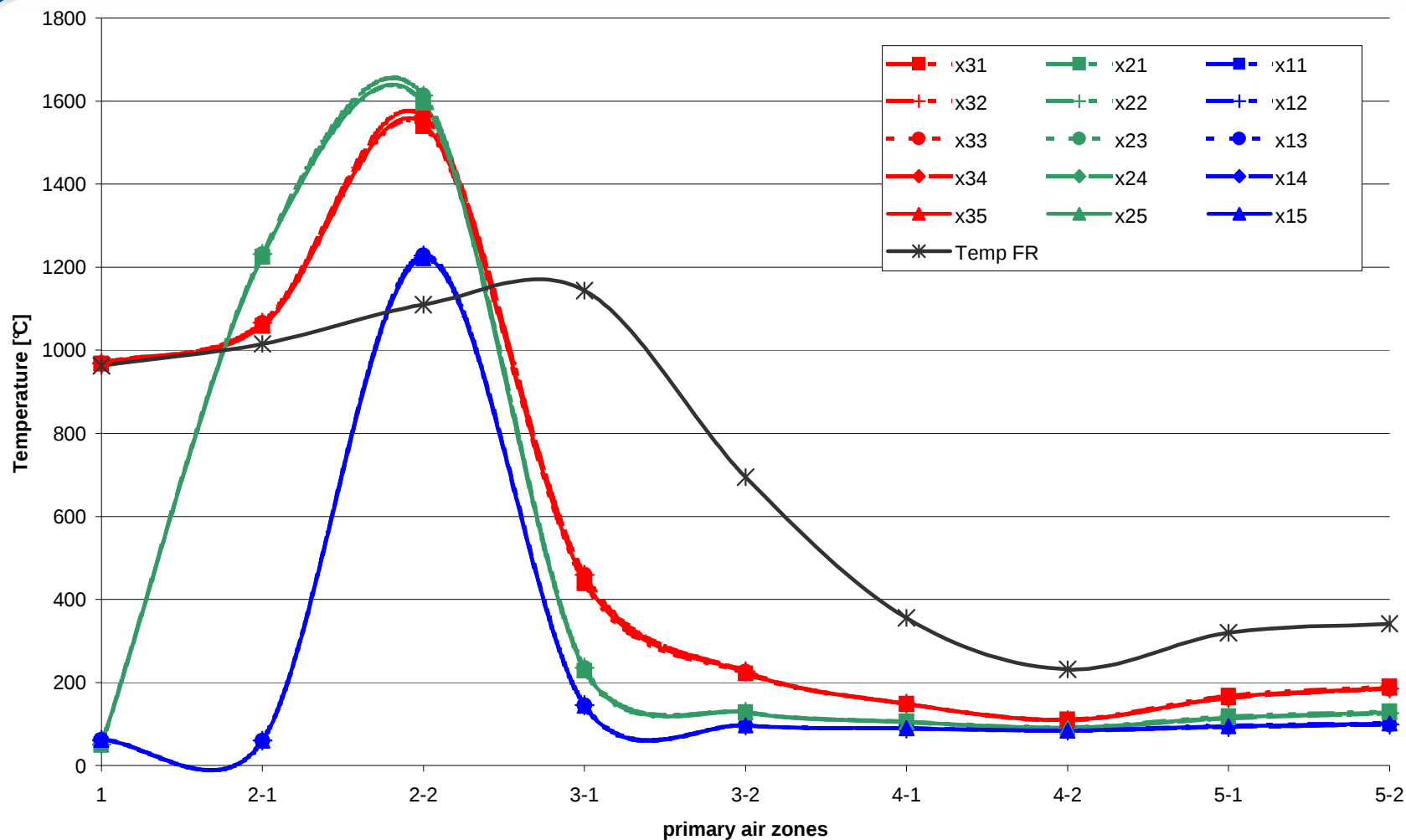


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Fuel-bed modeling - temperature of gas

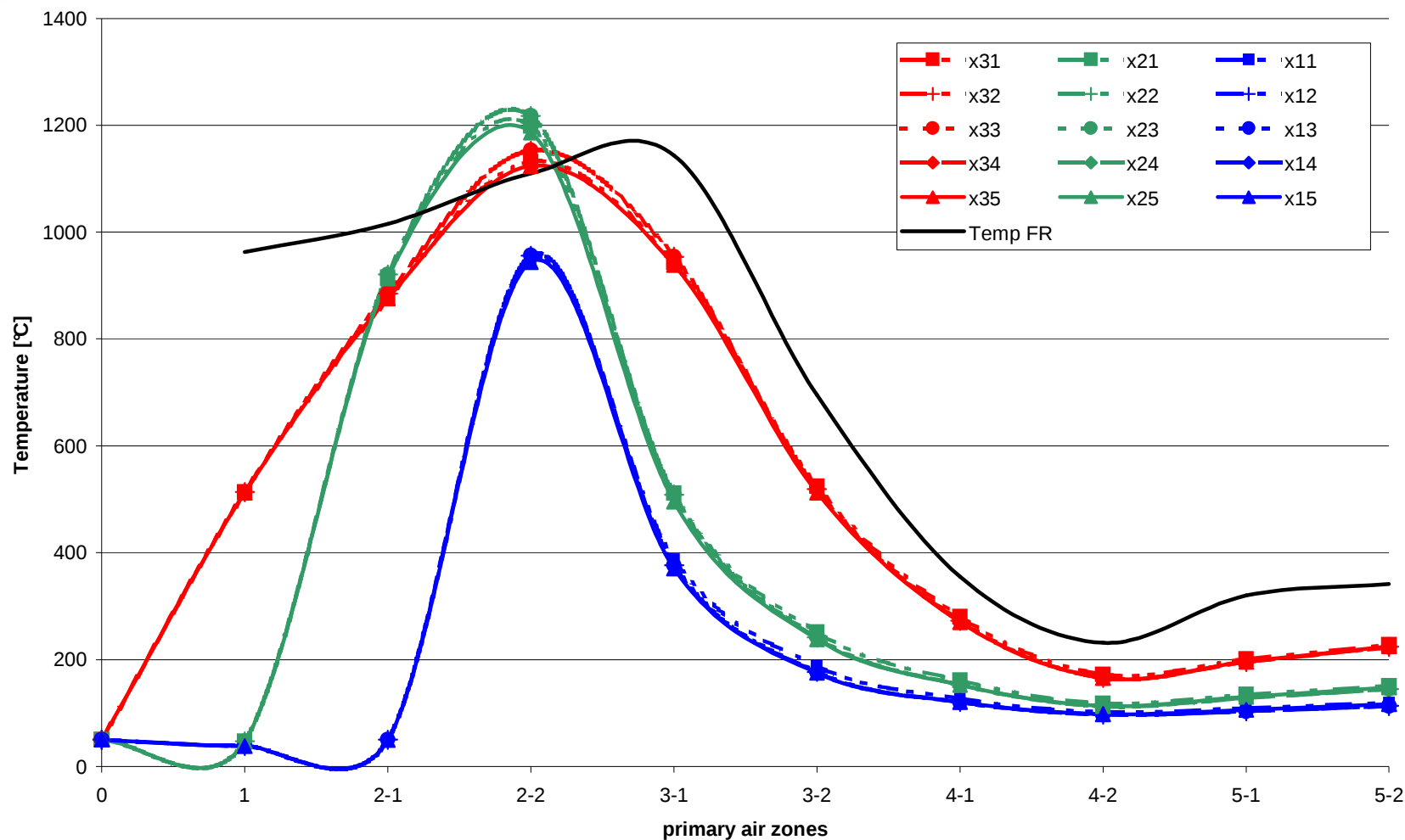


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Fuel-bed modeling - temperature of solids

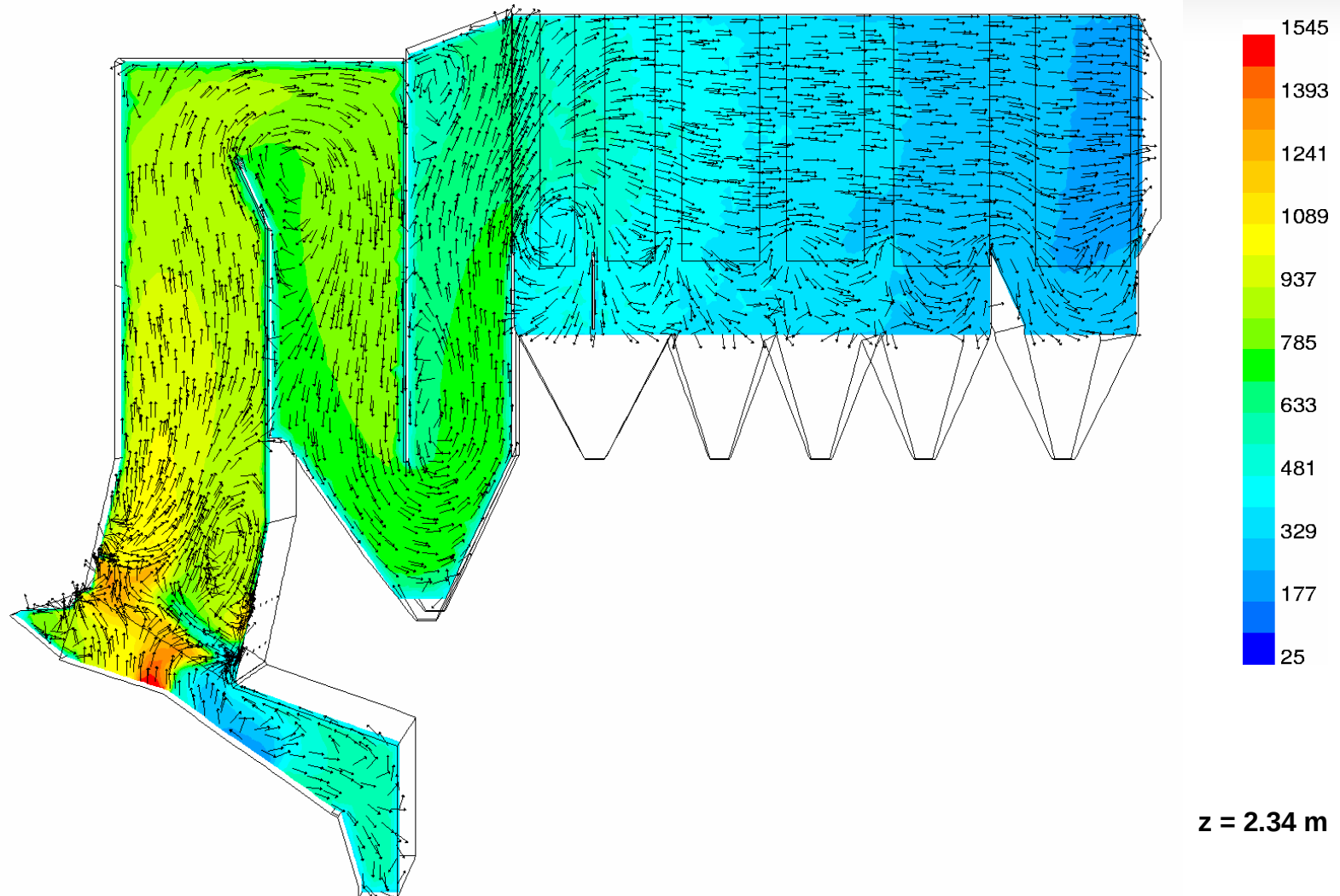


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CFD - profiles of temperature / velocity

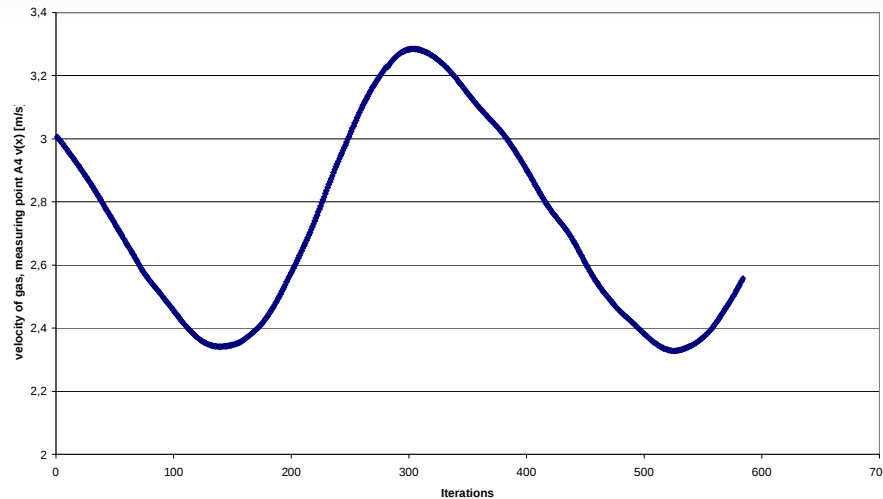


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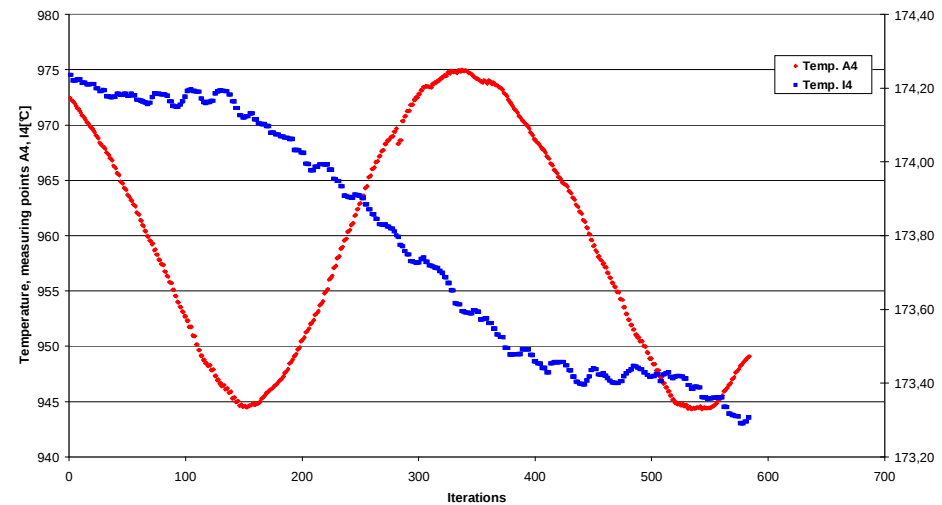


Statistical methods of CFD simulation



Gas velocity

Temperature

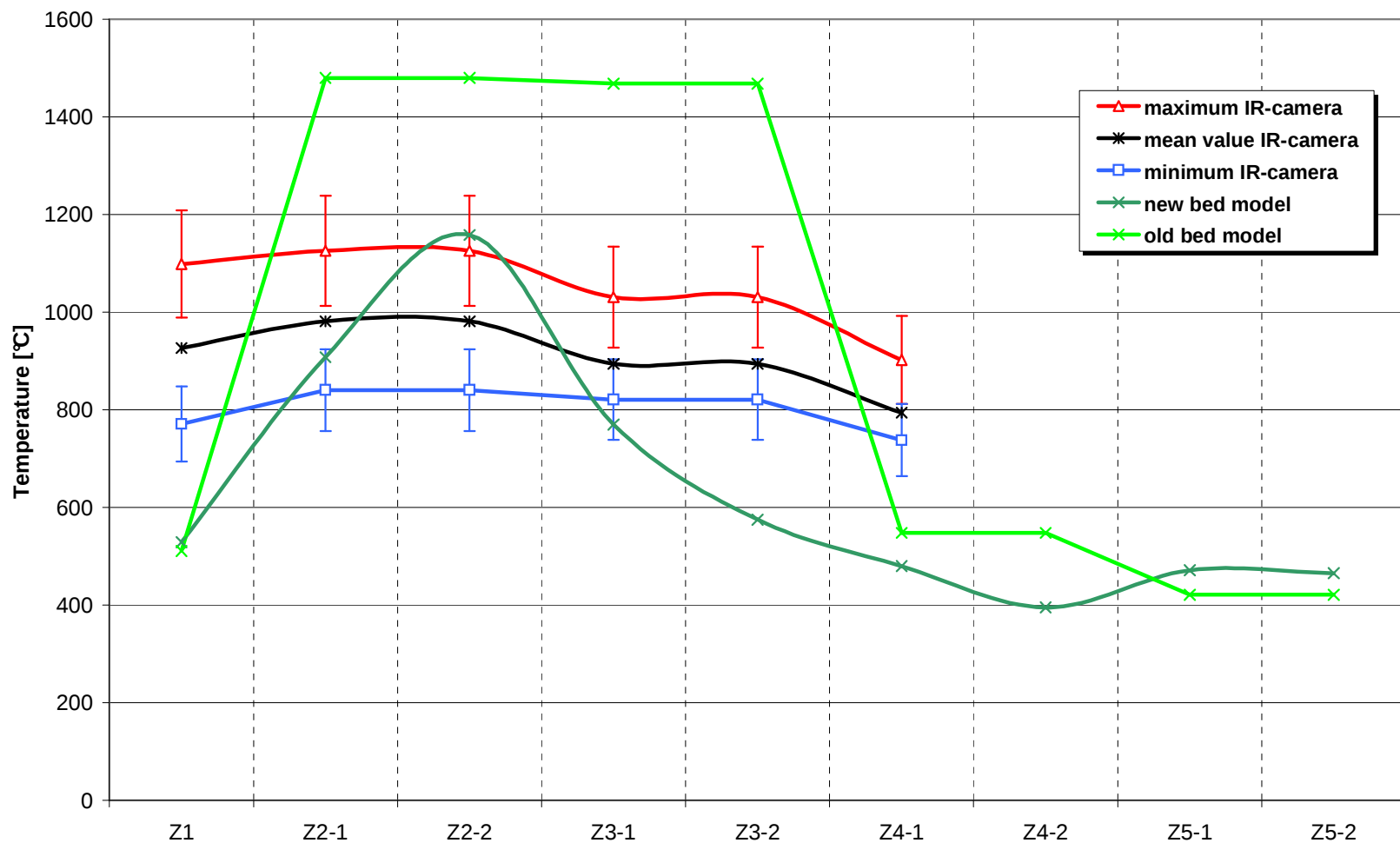


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Fuel bed - comparison measured / calculated temperatures



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Fuel-bed model - validation

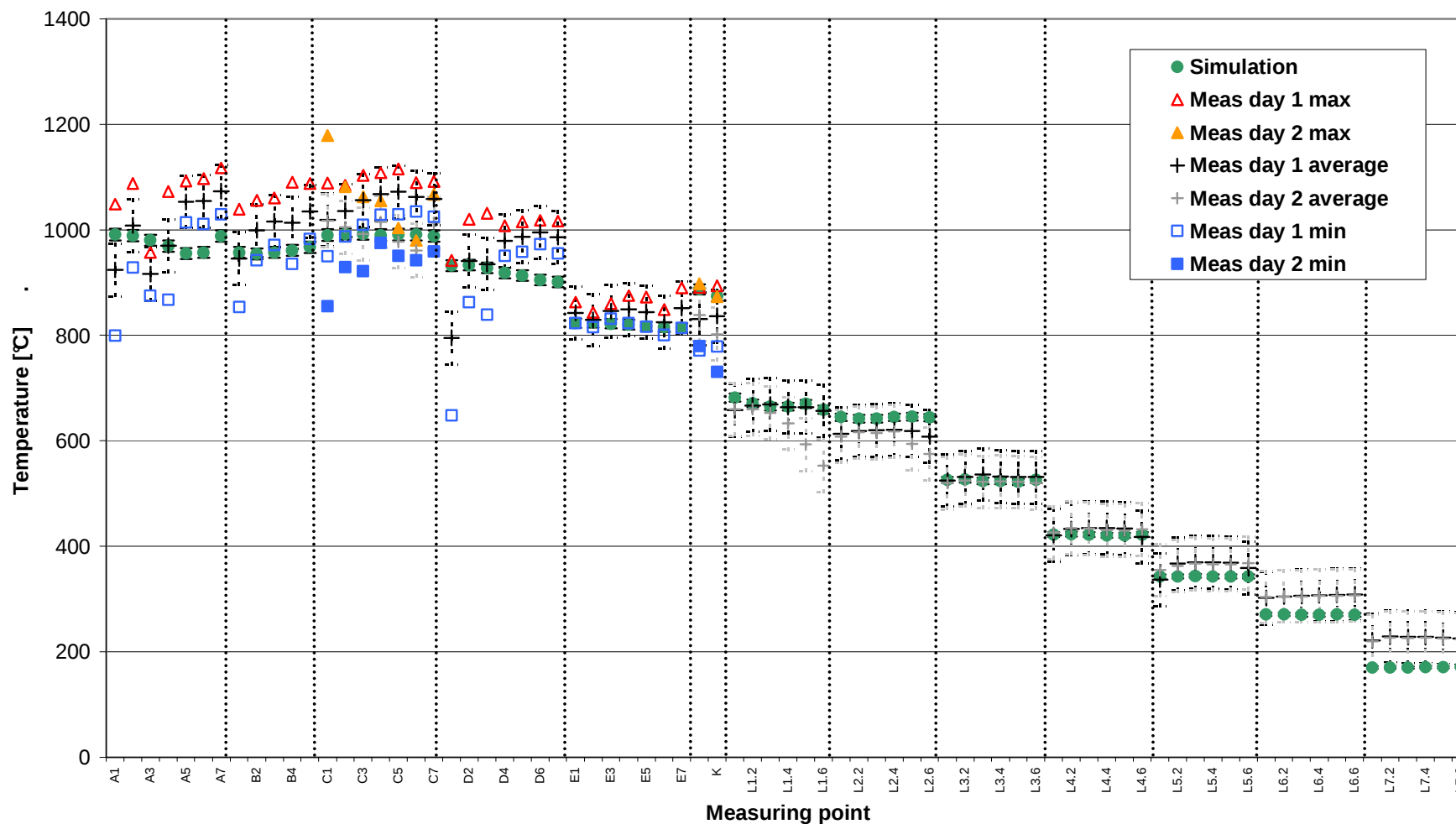
- The fuel-bed surface temperatures measured by the IR camera and the position of the main combustion zone correspond well with the model
- Temperatures measured inside and outside the fuel bed in the main reaction zone and at the end of the grate correspond largely to the calculated results
- The residence time forecast for inert test specimens on the grate is too short
- The one-dimensional assessment model significantly overestimates the maximum temperatures in zones 2 and 3

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Gas flow - comparison measured / calculated temperatures

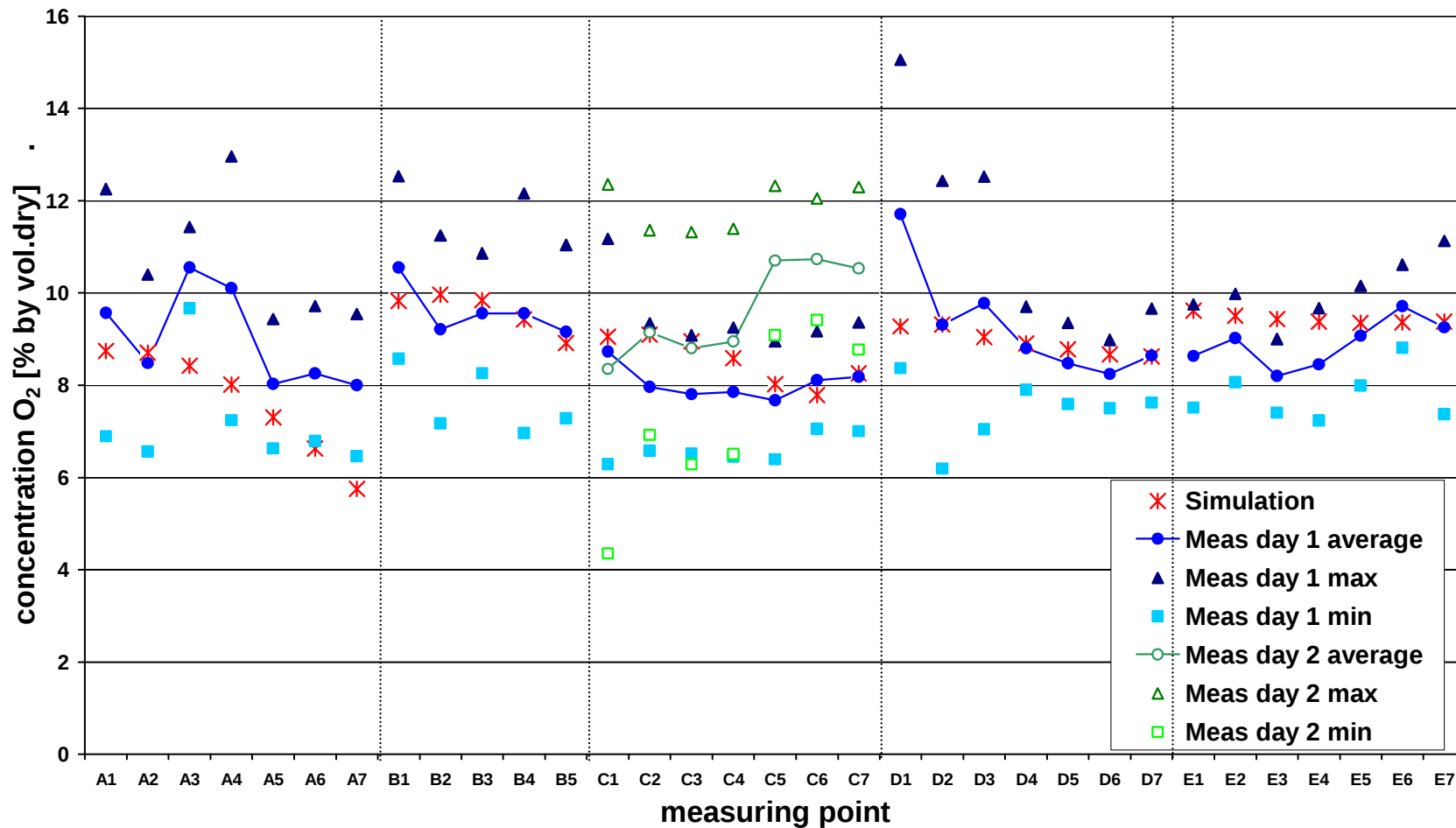


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Gas flow - comparison measured / calculated O₂ concentrations



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CFD - validation

- Temperature and flue-gas concentration values (CO_2 , O_2) show good matches
- The model for CO burnout and a number of simplified partial models (heat dissipation in the convective part of the heat exchangers) do not support accurate analysis or forecasting for these areas
- Velocity components are at variance due to the turbulence that prevails above all in the first pass of WTE plants; however, trends can be identified

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Summary

- **PROFILER II**
Significant improvement
 - description of the processes in the fuel bed
 - starting values
- **CFD**
 - Good matches for main gas flow parameters
 - No accurate analysis / forecasting for CO / some partial models / velocity vectors
- **Uncertainties / fluctuations of measured / simulated values**
- **Description of tendencies of combustion processes in a WTE plant**
- **Validation imperative**
- **Modeling options limited**

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Perspectives

- Commissioning of external companies / internal inspections
- Optimization of fuel-bed modeling
- Internal use of fuel-bed model PROFILER II

- Consideration of water-steam circuit
- Modeling as controller component (model-predictive controller)

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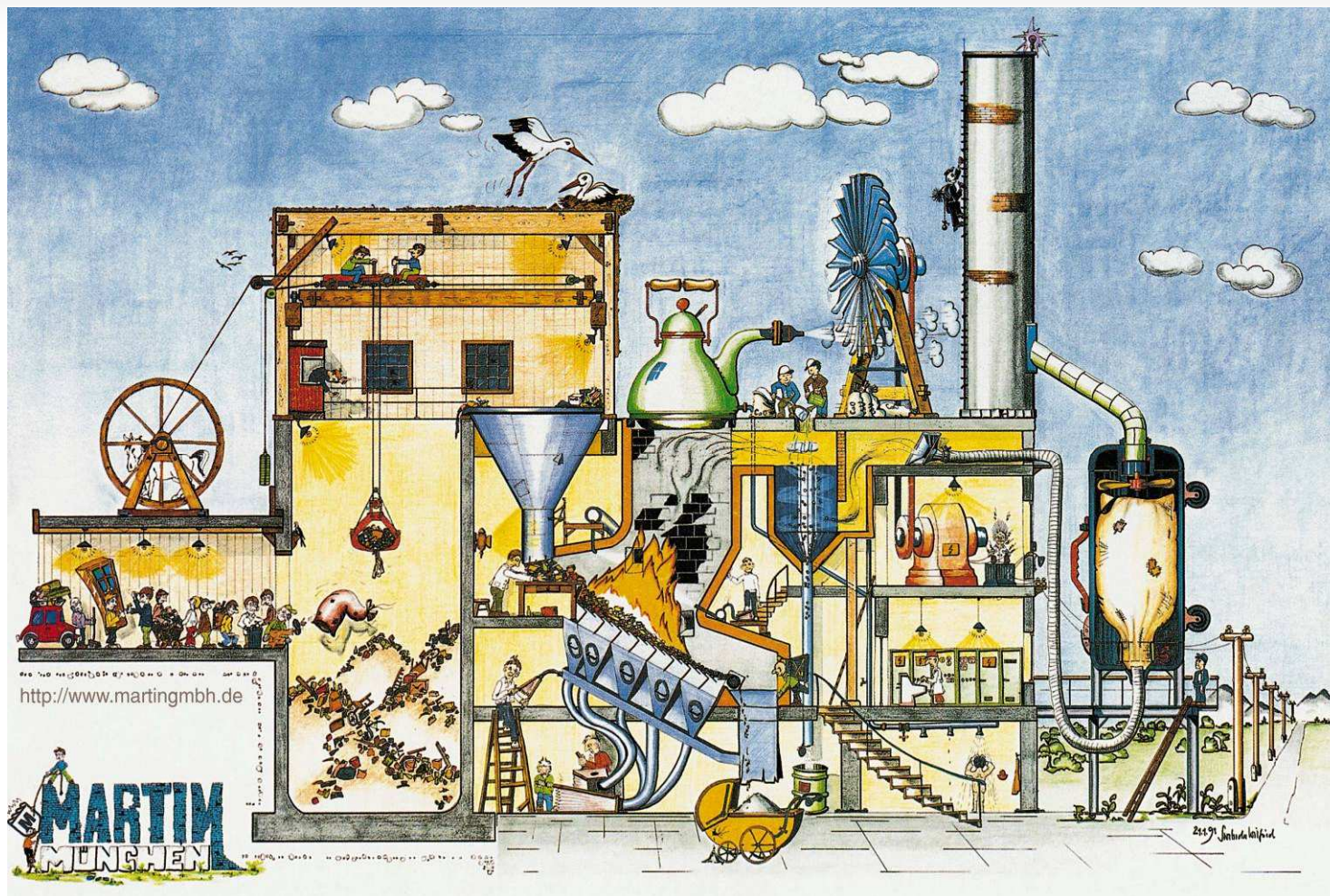


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