K1-MET

Competence Center for Excellent Technologies in „Advanced Metallurgical and Environmental Process Development“

Research Area 1 Project 3

Formation of nitrogen oxides in the heating system of a coke oven

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The project investigates the formation of nitrogen oxides in the heating system of a coke plant. The reaction mechanism and the combustion kinetics are implemented with the help of the CFD package FLUENT. The simulation tool is applicated to predetermined operating points of top gas and coke gas combustion in the heating system of the coke plant in Linz.

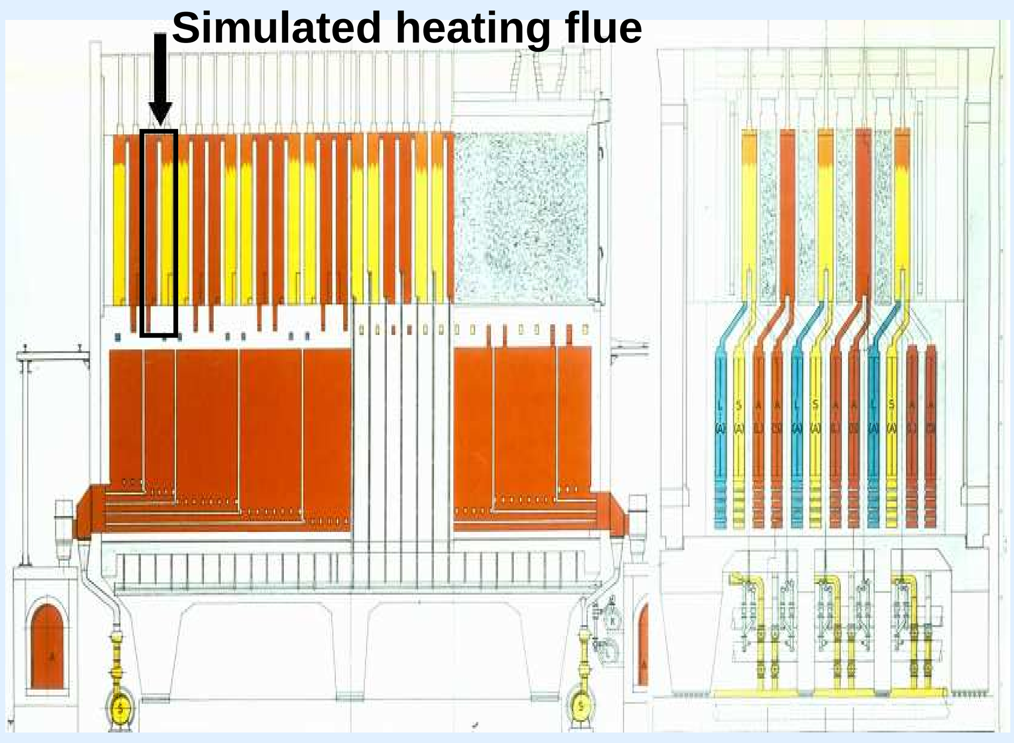
Project-Partners

Scope

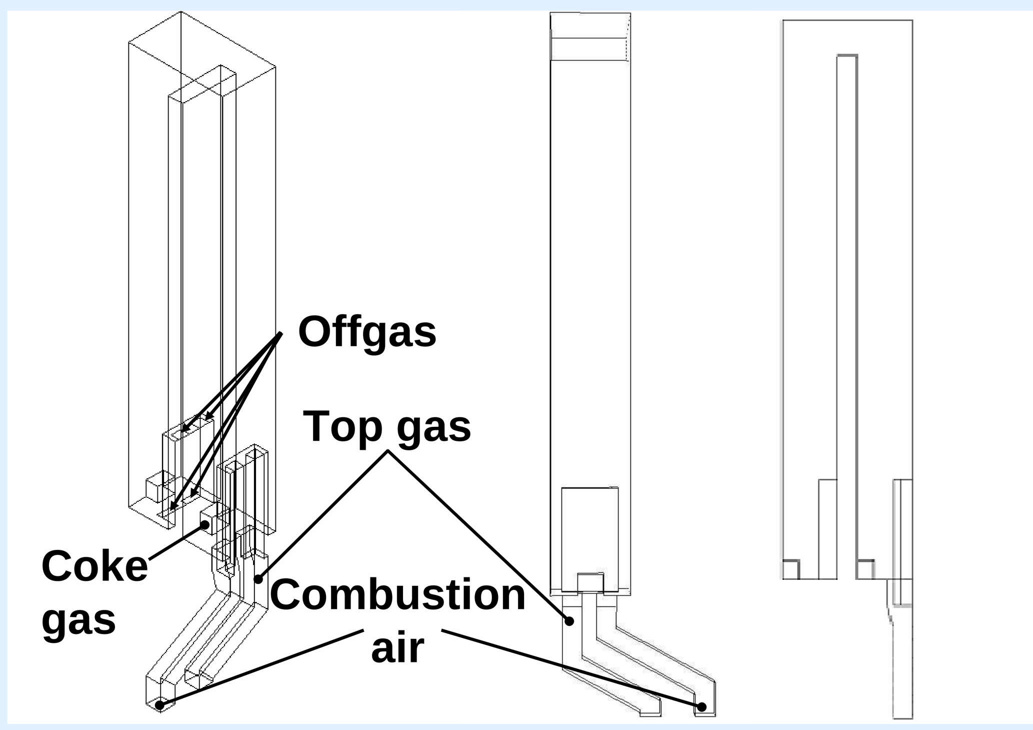
To predict the formation of nitrogen oxides in the heating system of coke plants, detailed information about the combustion process is needed. Due to the high temperatures in the heating system, the data cannot be measured. A model for a combustion chamber was generated for the computational fluid dynamics (CFD) package FLUENT 6.3. With this program the formation of thermal and prompt NO was simulated. Because of the unsteady conditions in the combustion chamber (variable ambient temperature and periodic change of hot coke and cold coal) a pseudo – steady state was assumed. To prove the model's ability to predict changes in the formation of NO due to different operating conditions, a set of operating points from the coke plant in Linz was used for the calculations. The results were then compared to literature.

Geometry of the model

The three – dimensional model used for the CFD is composed of two single heating flues which are combined to one twin flue. This twin flue is a small part of the heating wall of a coke oven. One wall consists of 26 single heating flues.



Picture 1: coke plant 5 in Linz. The yellow colour represents top gas, blue stands for combustion air and red for offgas.

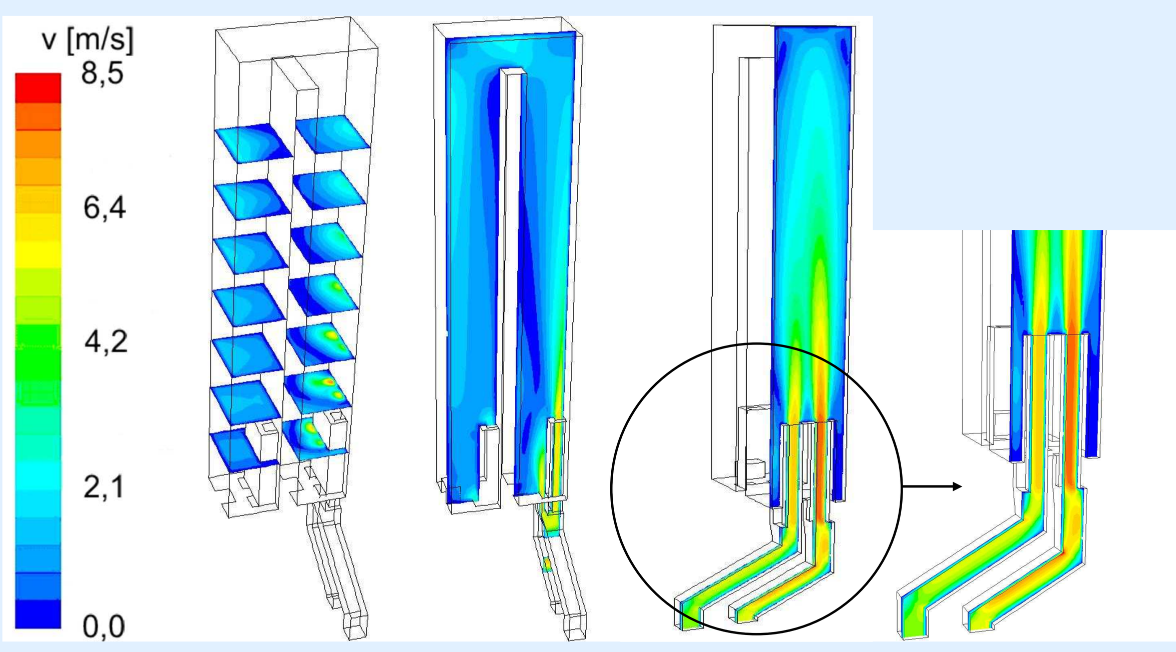


Picture 2: Simulated twin heating flue.

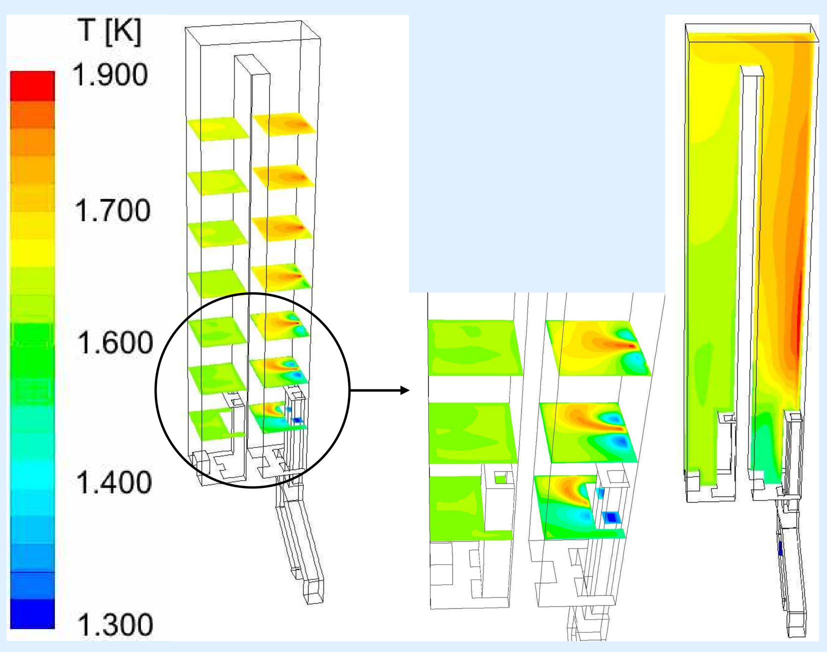
Methods

- Flow
  - Quasi stationary approach: Inherently unsteady operating conditions (variable ambient temperature, periodic change of hot coke and cold coal)
  - Three – dimensional
- Radiation
  - DTRM (Discrete Transfer Radiation Model): Discrete number of model beams which interact with gas phase by means of resorption and absorption
- Combustion kinetics
  - Non – premixed combustion
  - CH_4 – combustion mechanism: Mechanism with 7 boundary species,16 equilibrium species and 41 elementary reactions
  - Non – equilibrium chemistry
  - PDF – Model (Probability Density Function): Time dependent function describing the state and the composition of the fluid at a certain point
- Turbulence
  - Turbulent k – ε – Model
  - Flamelet – Model: Function describing the flame which develops when gas and combustion air stream in the combustion chamber.
- NO formation
  - Thermal (Zeldovich – Mechanism)
  - Prompt (Fenimore – Mechanism)

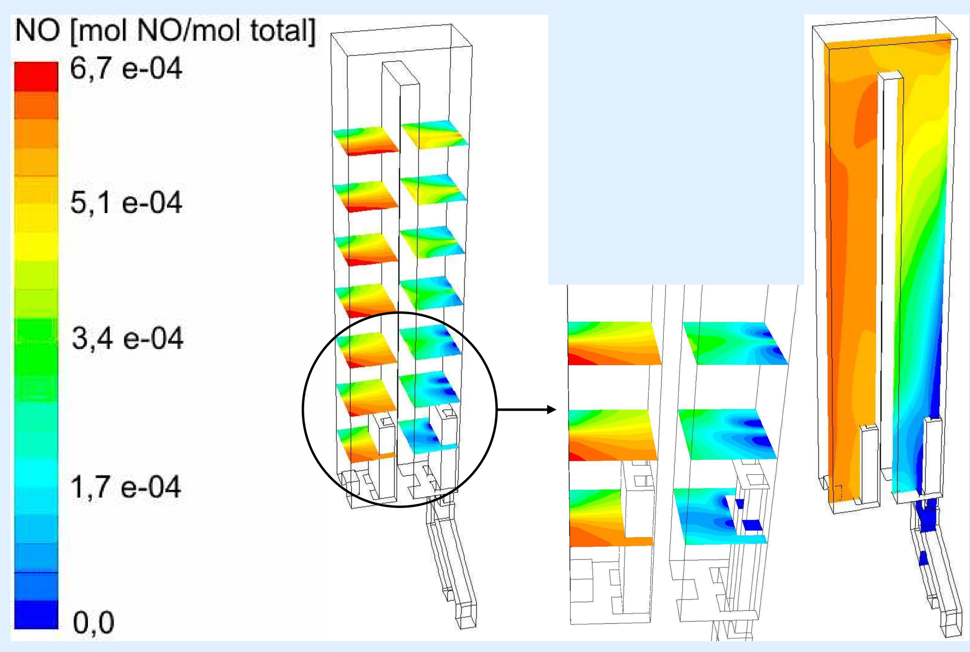
Illustration of the simulation results



Picture 3: Velocity distribution in the heating flue in m/s.



Picture 4: Temperature distribution in the heating flue in Kelvin.



Picture 5 : Molar NO distribution in the heating flue.