aixprocess

Simulation Services

Digital Solutions

Engineering Services

The ModeliNG Company

A First-Ever innovative brown-field modification in conservative cement industry - de-risked by smart simulation

Martin Weng, Matthias Schumacher

portfolio

- **established 2001**
  by Dr. Martin Weng, Markus Hufschmidt
- **owner-operated**
- **located in Aachen / Germany**
- **25 staff**
  - 16 process engineers
  - 9 data & ML specialists

Simulation Services

- CFD process simulation
- *SolidSheet* process modeling
- process optimisation

Digital Solutions

- **aixProM** software platform
- **aixProM** i-sensors
- **aixProM** Big Data Analytics

Engineering & Products

- cyclones
- advanced flow equipment
- basic & detail engineering

Dyckerhoff plant Lengerich / GER

Plant Overview

Kiln 4:

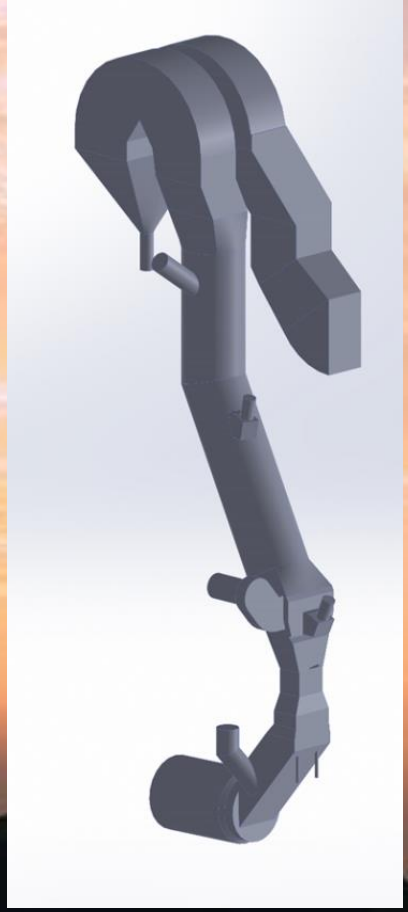
- Capacity: 1500 tpd
- Kiln: ∅ 3.2/3.8 x 48 m, Polysius, modified in 1980
- Preheater: 1 string, 5 stages, Polysius, 1980
- Cooler: IKN/CPAG, 1980
- Filter: Baghouse, RD42, 2018
- Fuels: Lignite, RDF, solvents

Kiln 8:

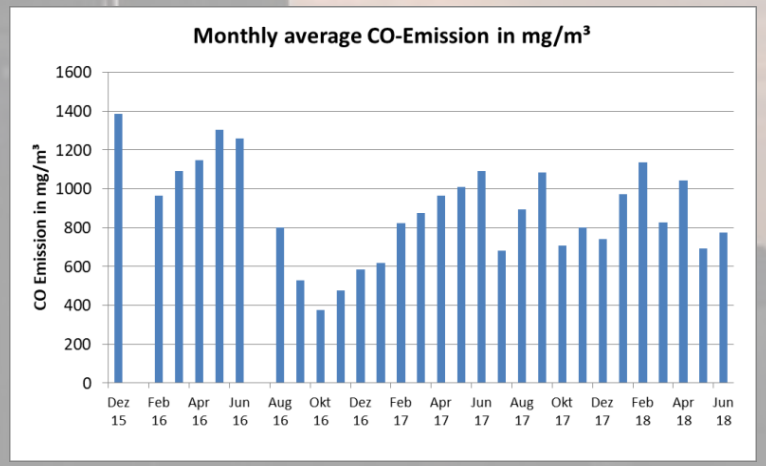
- Capacity: 3700 tpd
- Kiln: ∅ 4.55 x 58 m, FLSmidth, 2001
- Preheater: 2 strings, 6 stages, FLSmidth, 2001
- Cooler: IKN, 2001
- Filter: Baghouse, RD42, 2018
- Fuels: Lignite, RDF, solvents, wet sewage sludge

Calciner Kiln Line 4

Background and Tasks



- Calciner designed for lignite-firing
- Short calciner with low retention time (2-3 s)
- Exceptional CO-emission under injection of typical fluffy calciner RDF
- Moderate, but still elevated CO-emission under injection of “expensive” pelletized and pre-ground RDF
- Coal-free calciner operation not possible



Make the calciner ready for 100% TSR with low CO emissions

Size of Alternative Fuels

Pre-ground RDF Pellets

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Class 1

Class 2

Class 3

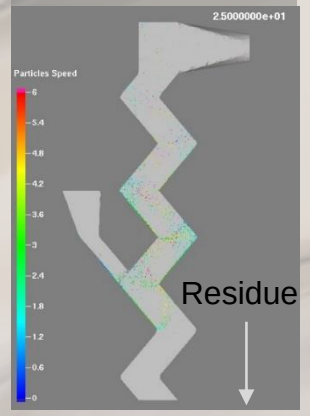
Class 4

Class 5

Class 6

Zig-Zag-Sifter

V_{gas}=16.0 m/s

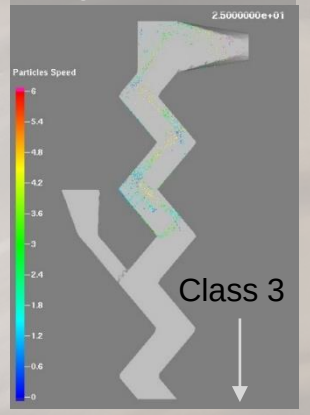


V_{gas}=14.3 m/s

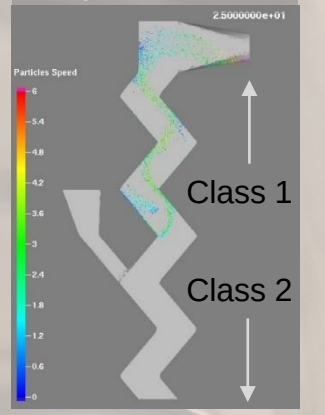
V_{gas}=10.1 m/s

V_{gas}= 7.8 m/s

V_{gas}= 5.8 m/s



V_{gas}= 2.5 m/s



Size of Alternative Fuels

RDF Pellets vs Fluffy RDF

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PRE-GROUND PELLETS

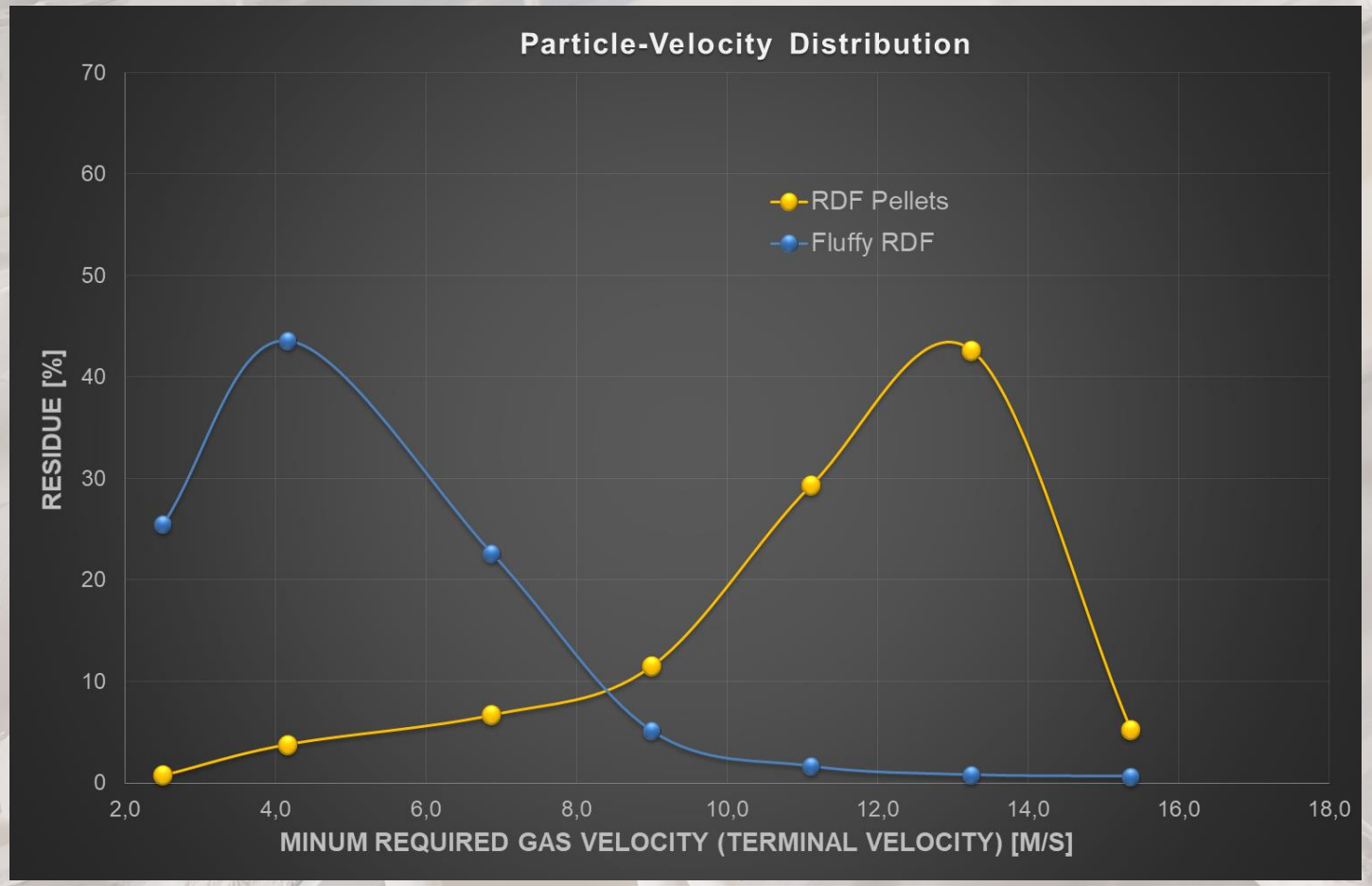
Class 1	Class 2	Class 3	Class 4	Class 5	Class 6
					

FLUFFY RDF

Class 1	Class 2	Class 3	Class 4	Class 5	Class 6
					

Size of Alternative Fuels

RDF Pellets vs Fluffy RDF

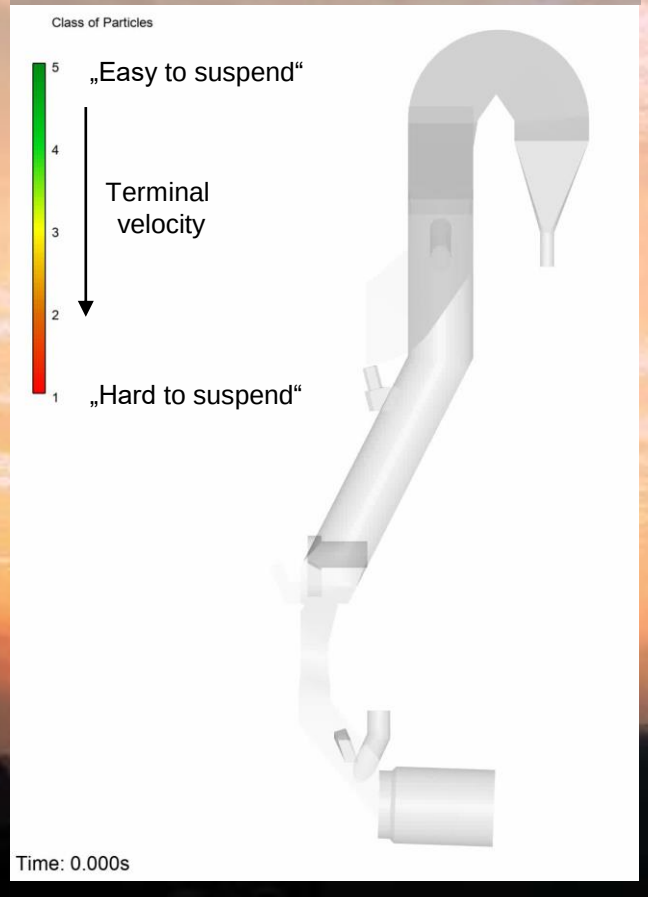


- Pre-ground pellets require higher minimum gas speed for safe pneumatic transport
- Coarse particles burn slower and produce more CO than fine ones
- Why is this particular calciner producing less CO with the pellets?

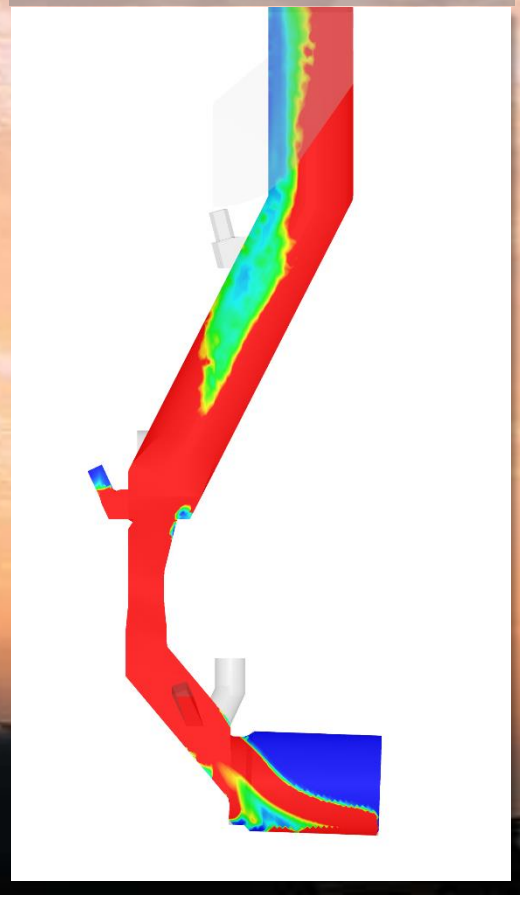
CFD-Analysis of the current operation

Fired with pre-ground RDF Pellets

Motion of the Pellets



CO concentration

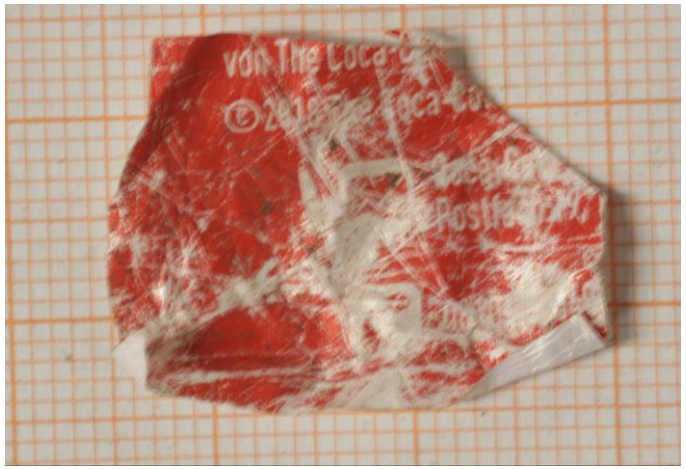


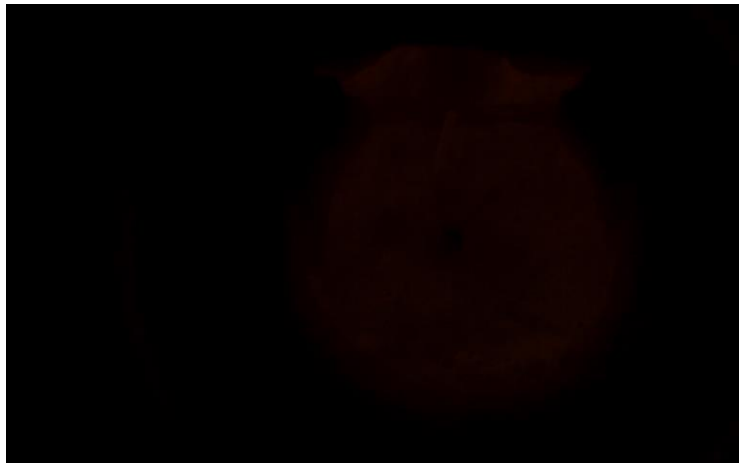
CO concentration

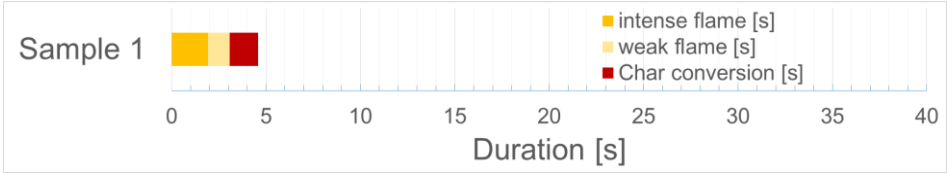
- Fuel rain out into the kiln inlet
- Fluidized bed of the pelletized particles in the inclined part
- CO is permanently produced from the layer at the bottom
- CO/O_2 stratification in the riser
- CO oxidation in the double deflector
- CO Emission >1000 mg/Nm³

Combustion of RDF particles

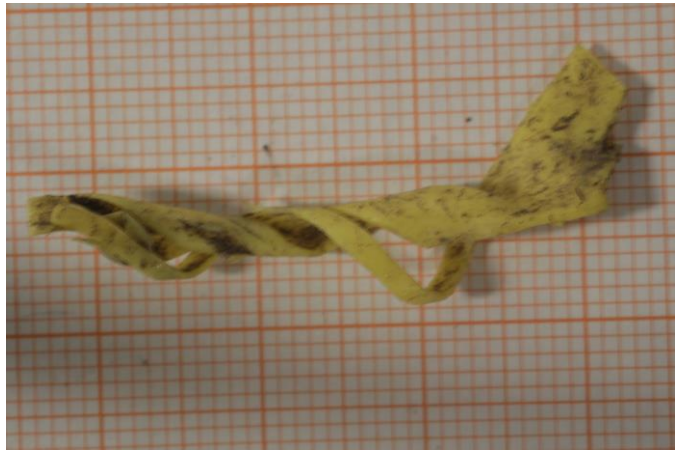
Lab furnace tests

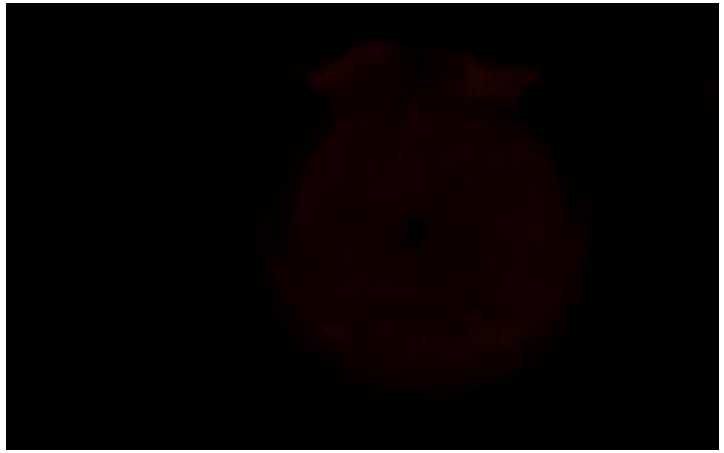


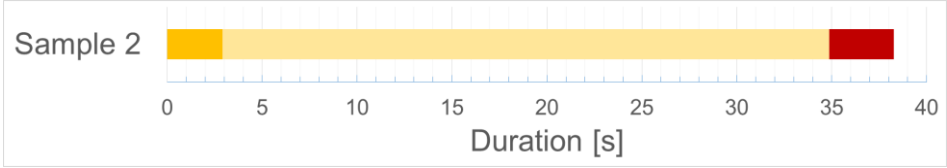




Type: 2D
Size: 25 x 25 mm
Weight: 12 mg



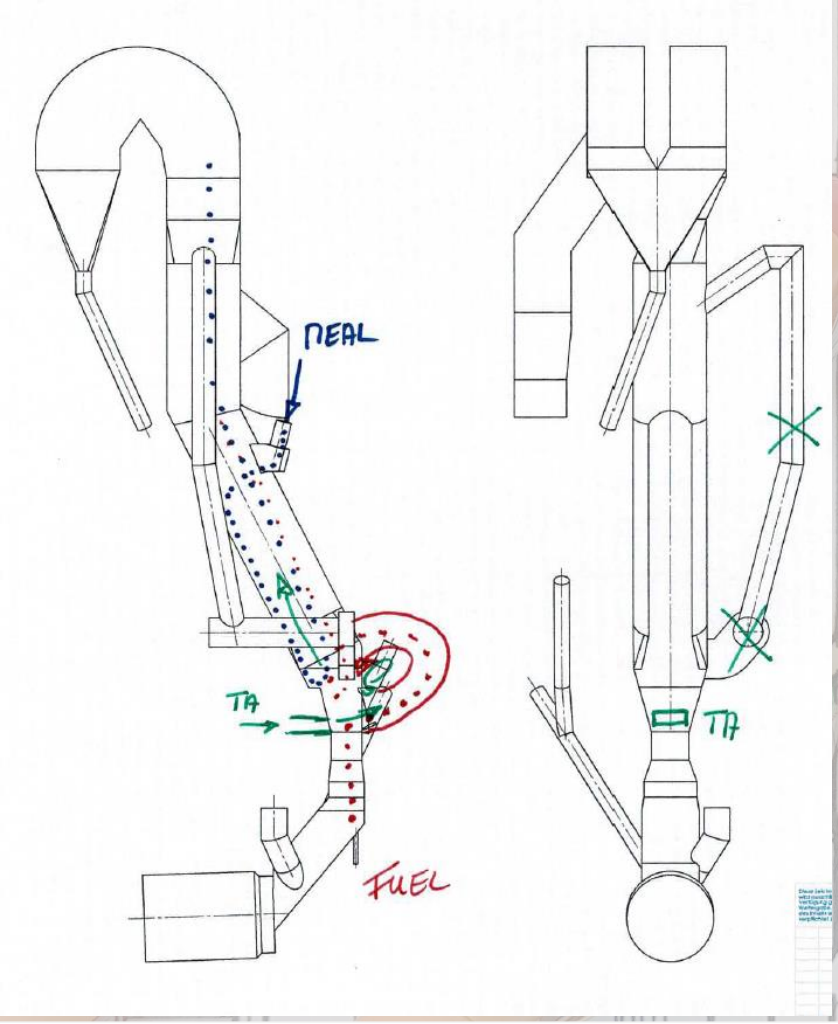




Type: 3D
Size: 30 x 5 mm
Weight: 140 mg

Development of a smart retrofit concept

Brainstorming phase



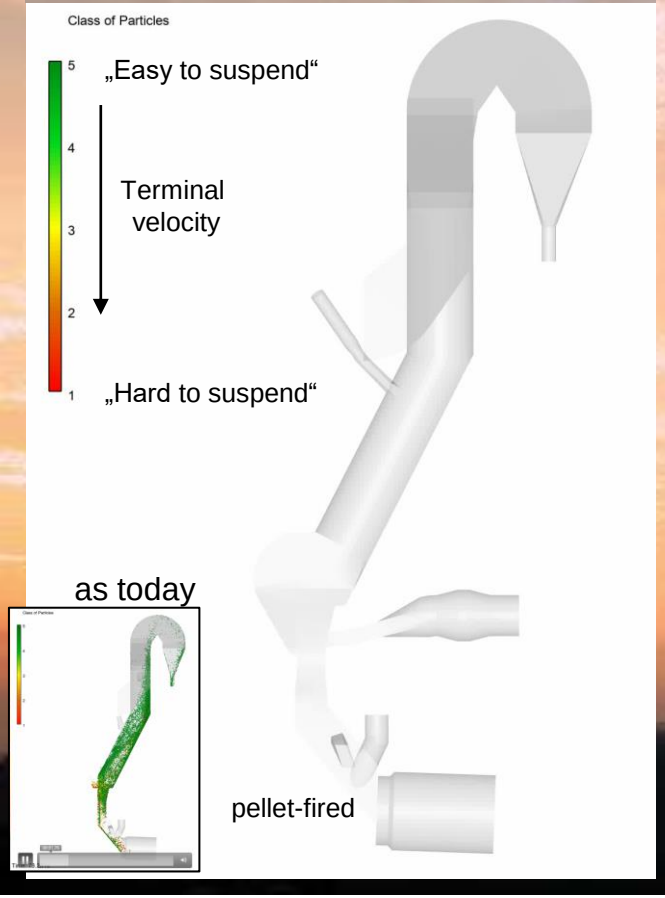
- CO emissions can be reduced by
  - Increasing temperature
  - Improving oxygen availability for the fuel
  - Enhancing retention time for the fuel
- Fluffy RDF is carried straightly through the calciner – limited by retention time
- Coarse high-dense particles are producing high CO emissions due to local lack of oxygen – limited by mixing
- Concept as developed by the Lengerich engineers

  Installation of a pre-combustion chamber to increase retention time and to improve mixing

CFD-Evaluation of the future operation

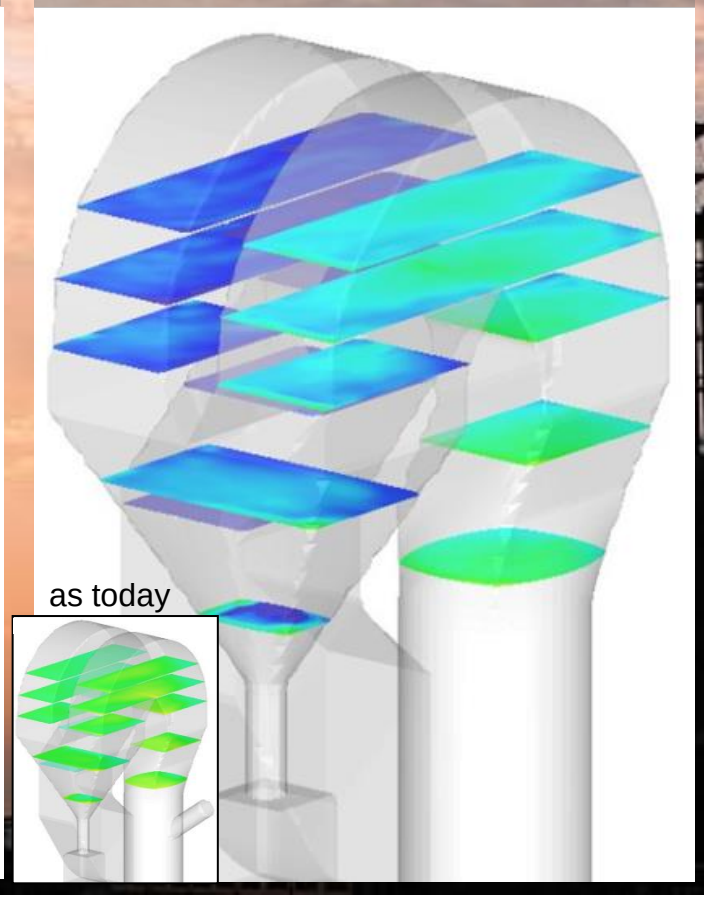
Fired with pre-ground pellets

Motion of the Pellets



CO concentration

CO concentration

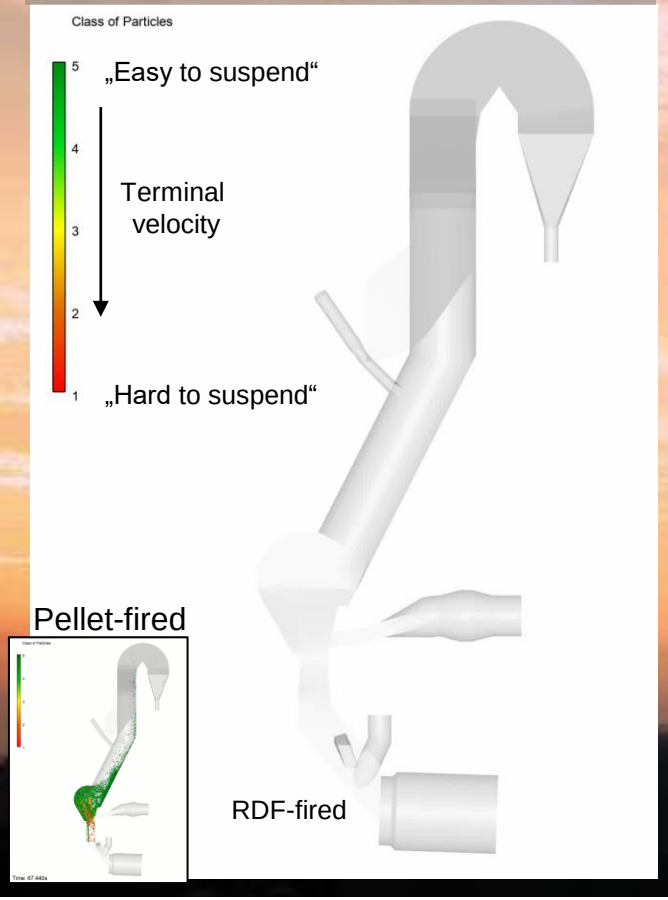


- Fuel particles swirl in the pre-combustion chamber
- Fuel particles remain in the hot bottom section
- Reduced fall-through, only very coarse particles rain into kiln inlet
- CO Emission reduction by >70% compared to todays operation

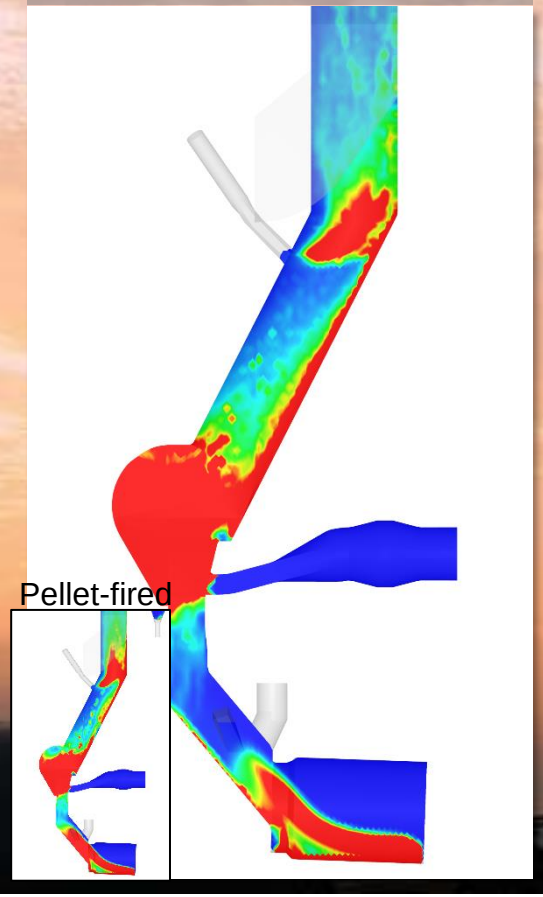
CFD-Evaluation of the future operation

Fired with fluffy RDF

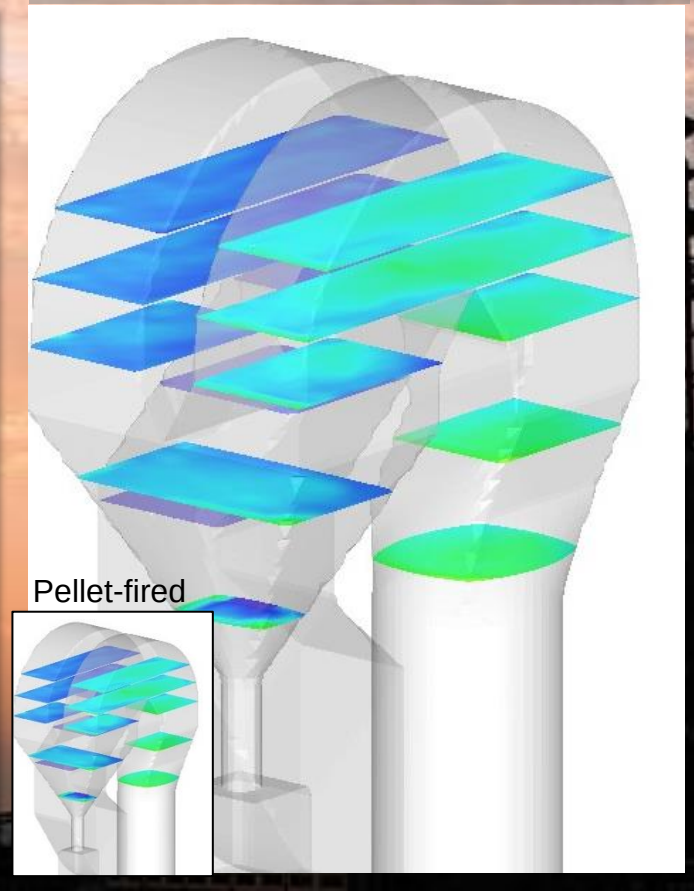
Motion of the RDF



CO concentration



CO concentration

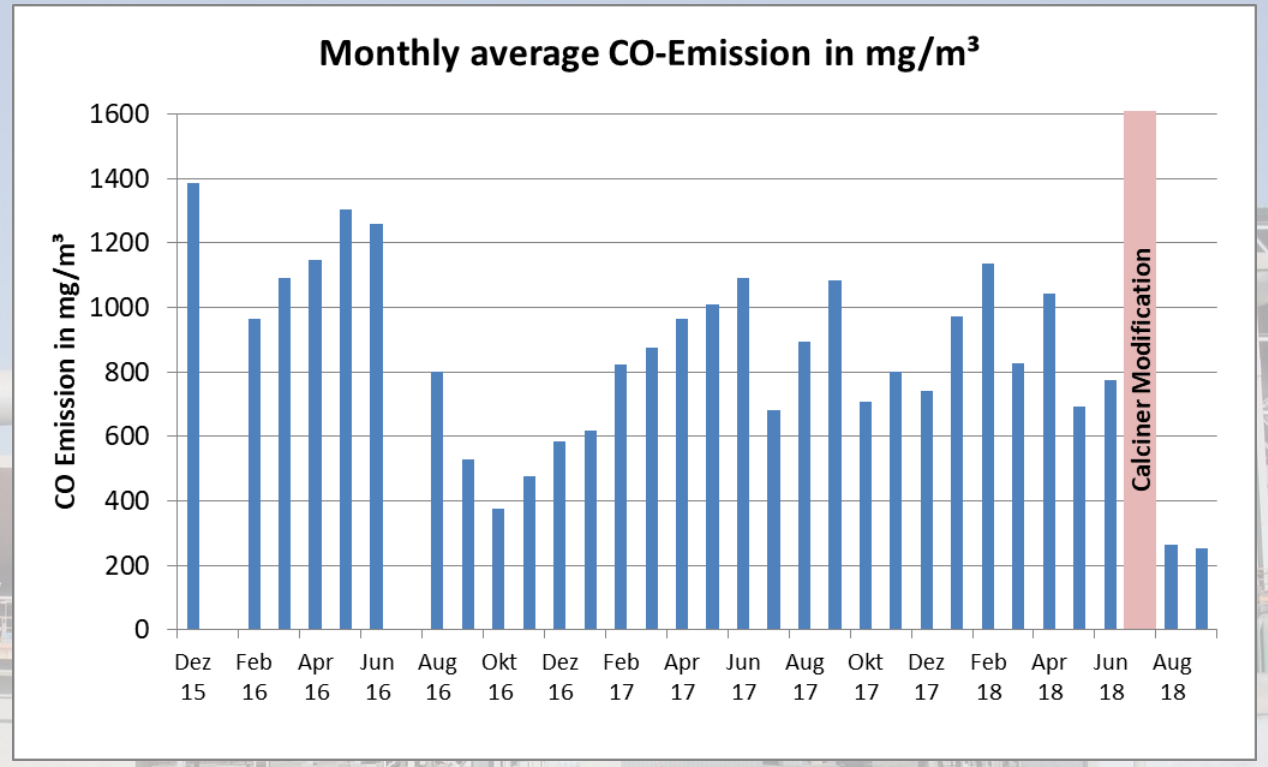


- Introduction of fluffy RDF is technically feasible
- CO emission slightly increases with typical RDF again
- Still significant reduction of CO emissions compared to today (>60%)
- Fuel cost expenditures drastically reduced

CFD-Evaluation of the future operation

Flight through the calciner

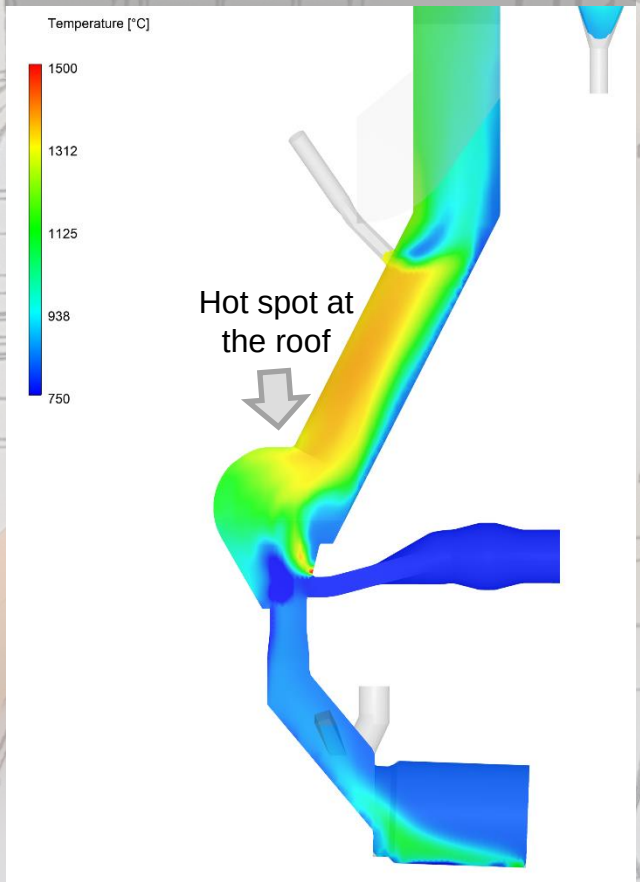
Operational experience

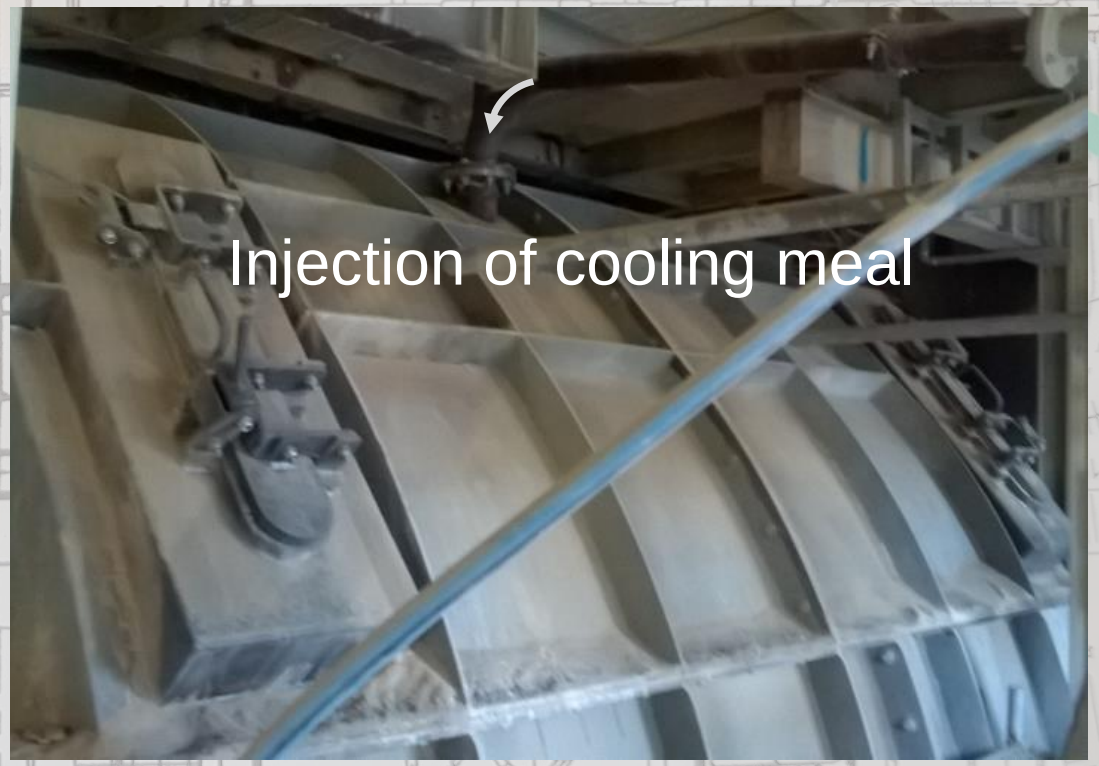


Emisson reduced by 70-80% after start-up

Further improvements

Gas temperature





Economical Benefits

- Increase of the total substitution rate (TSR) by 22 %-points
- Reduction of the fuel costs through substitution of lignite by RDF (1.40 €/ton clinker)
- Additional reduction of the fuel costs due to elimination of the pre-ground pellets (1.00 € /ton clinker)
- Total fuel cost savings: 2.40 €/ton clinker
- Return on investment in less than 6 months

Take-Home Messages

- Our CFD studies have proven to be exact in a way to project the effect of future plant modifications – even for minority components like CO (measured in ppm)
- Due to the lack of reference experience for comparable modifications only detailed modeling and simulation could check the viability for this unique optimization proposal
- The proposed unconventional retrofit has proven to be successful and the project objectives could be reached
- Additional benefit could be generated by downgrading the alternative fuel quality leading to substantial fuel cost savings without jeopardizing operational stability
- Careful engineering and simulation has led to total project success with an RoI < 6 months