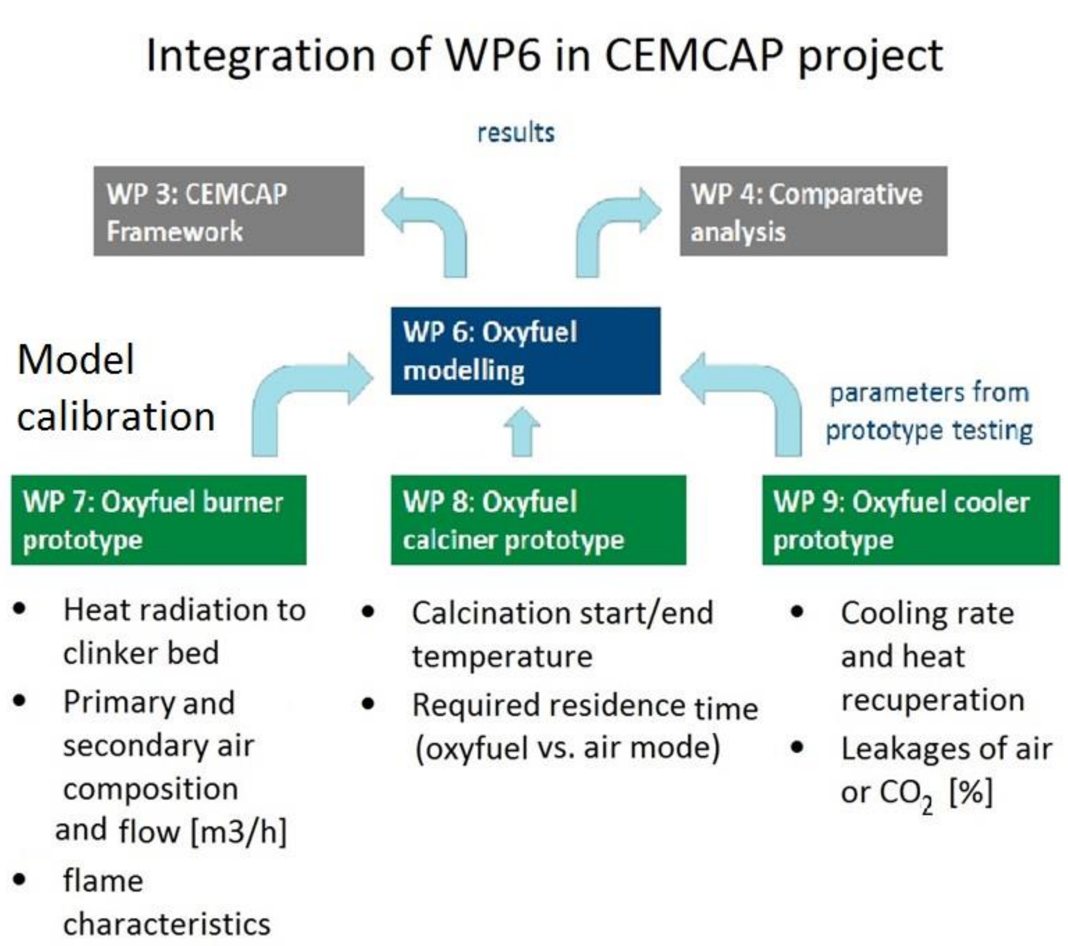
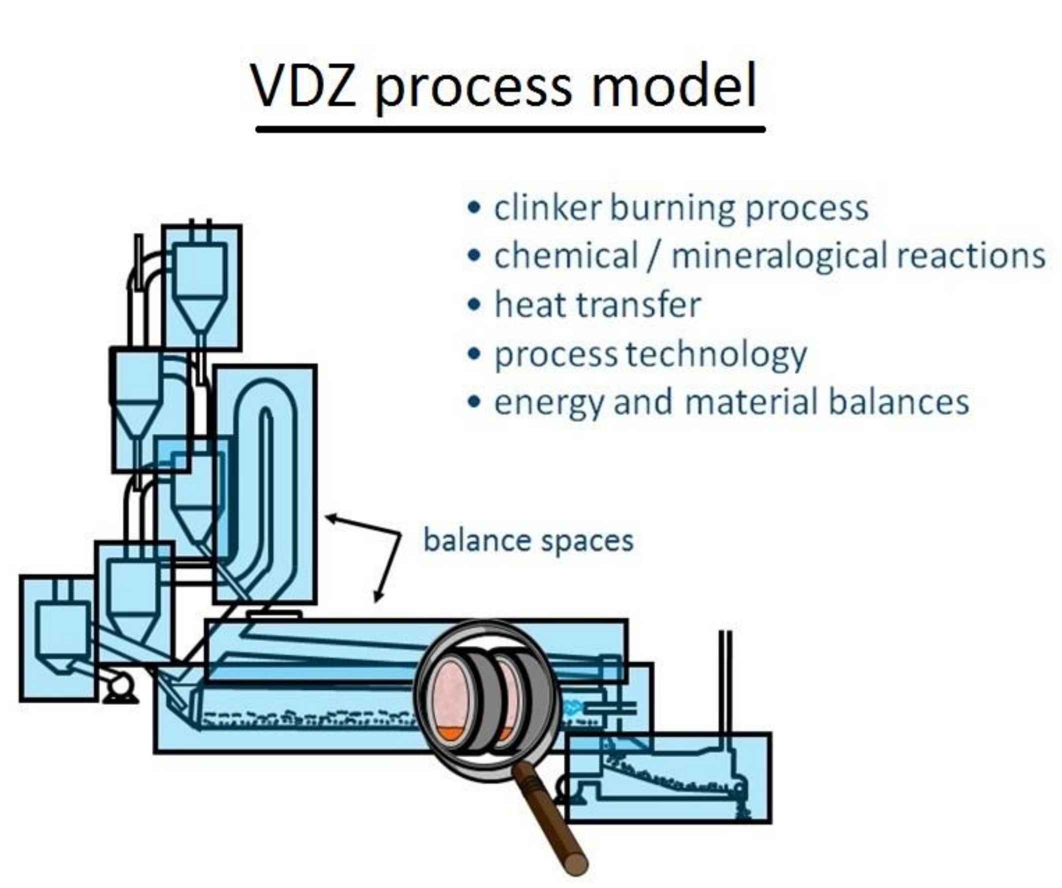
WP6 Oxyfuel modelling

CEMCAP

CEMCAP is a Horizon 2020 project with the objective to prepare the grounds for cost- and resource-effective CCS in European cement industry.





Objectives

- Integration of the pilot-scale experimental results into the overall concept and design of an oxyfuel cement plant by process modelling.
- Optimisation of energy efficiency: thermal and electrical energy demand
- Prove cement clinker product quality under the changed overall production conditions

Conclusions

- It is feasible to produce clinker with high quality under oxyfuel operation conditions (assessed by modelling for calcination and cooling process).
- Regular maintenance will be essential to reduce false air ingress in the oxyfuel clinker burning process and thus the electrical energy demand in the CO_2 purification unit (CPU).
- Additional fuel input can yield good efficiency of energy recovery by an Organic Rankine Cycle (ORC).

Work package 6 research activities

Assessment of the cement clinker product quality under simulated oxyfuel calcination and cooling conditions

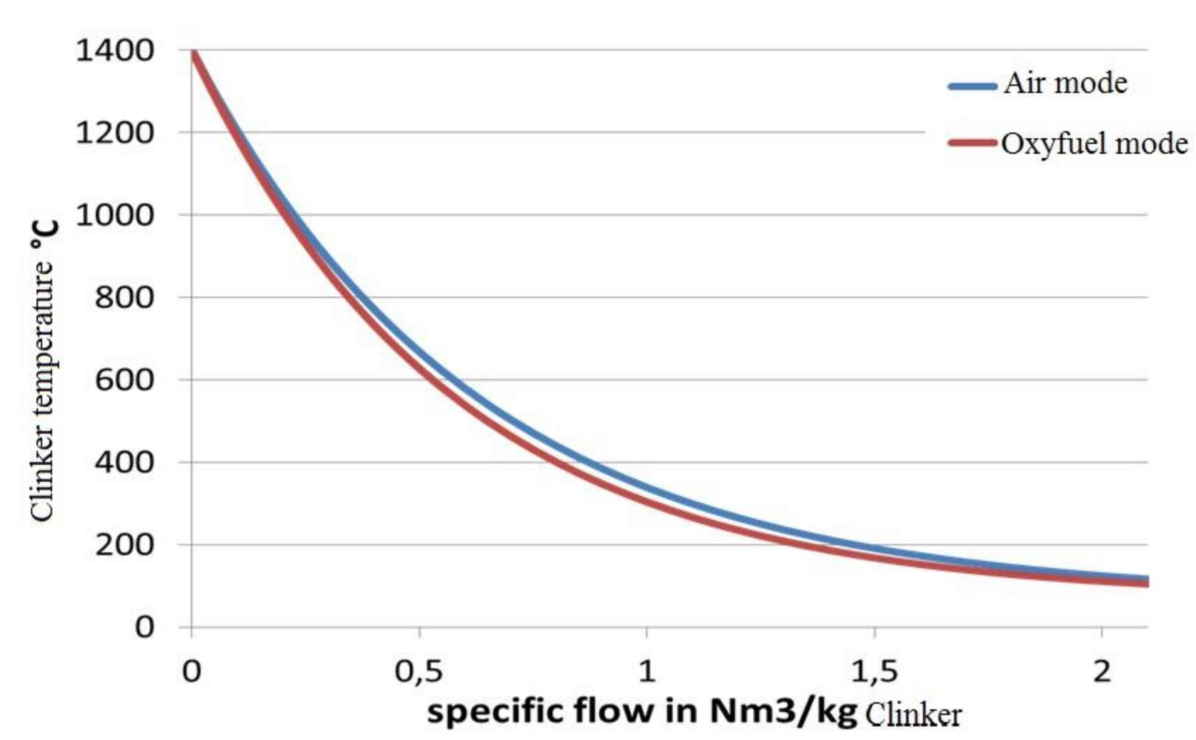
Good agreement found between process model assumptions and WP8/ WP9 experimental results regarding:

- Calcination start and end temperatures.
- Residence time.
- Clinker composition.

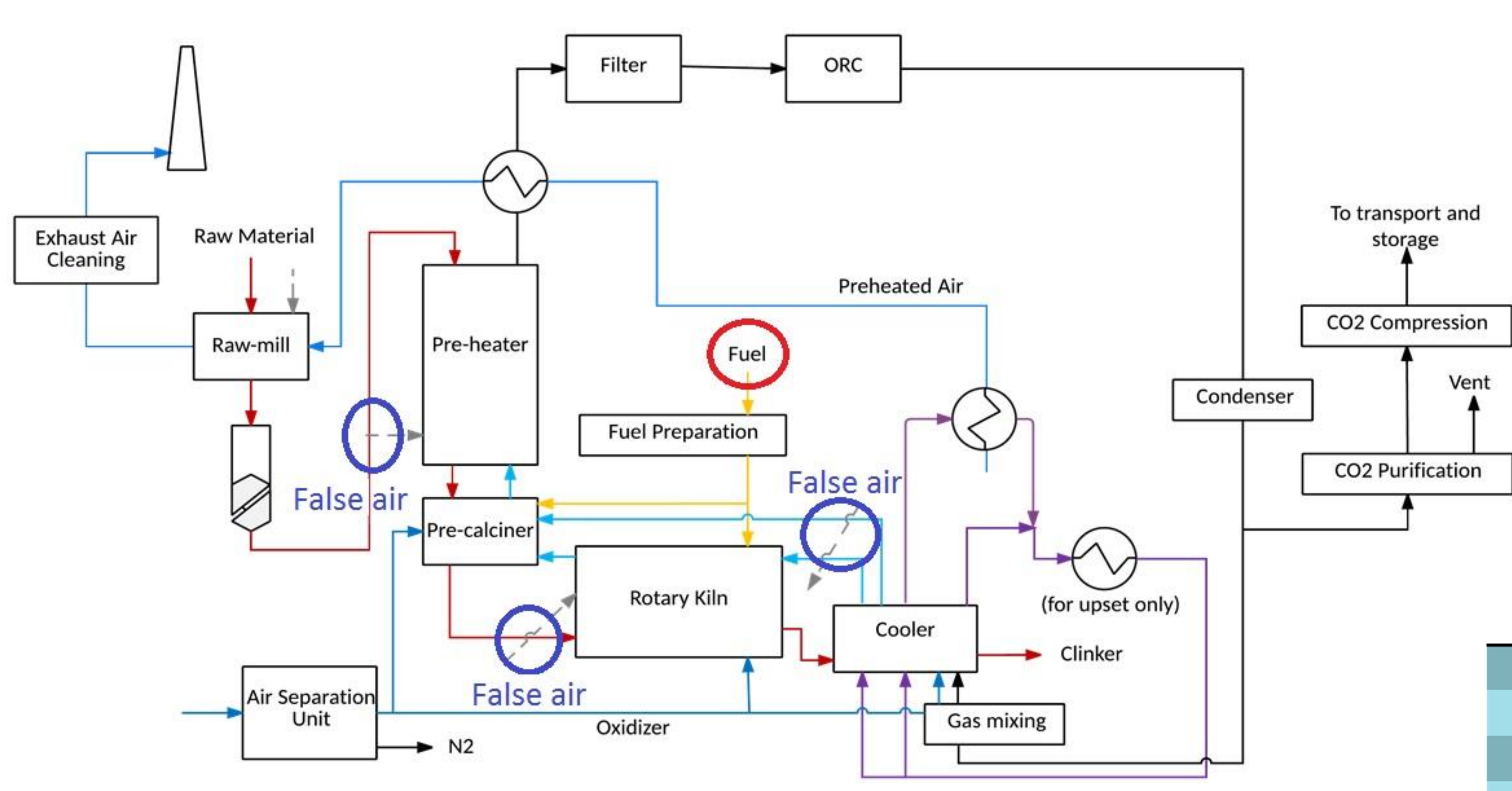
Calcination Oxy case	Model assumptions	Experimental results WP8	Experimental results WP9
Start temperature [°C]	565	610	
End temperature [°C]	970	980	
Residence time [s]	3.6	3	
Thermal enrgy demand [kJ/kgClinker]	3100	3100	
Clinker quality			
	Modelled assumptions	Modelled experimental results WP 8	XRD analysis
Alite (C3S)	65.4	64.8	64.3
Belite (C2S)	13.1	13.6	17.4
Free lime (CaO)	0.0	0.0	0.83

Adaptation of the VDZ process model to the CEMCAP oxyfuel experimental results

- For the simulations of the oxyfuel clinker cooler based on the experimental results the boundary conditions (cooling medium composition and volume flow) for different operations (oxyfuel and air mode) could be determined.
- The diagram showed a higher cooling rate for the oxyfuel mode(CO_2 68%, H_2O 10%, O_2 21%, N_2 1%) than for air mode at the same. operation conditions.



Evaluation of effects of increased false air ingress

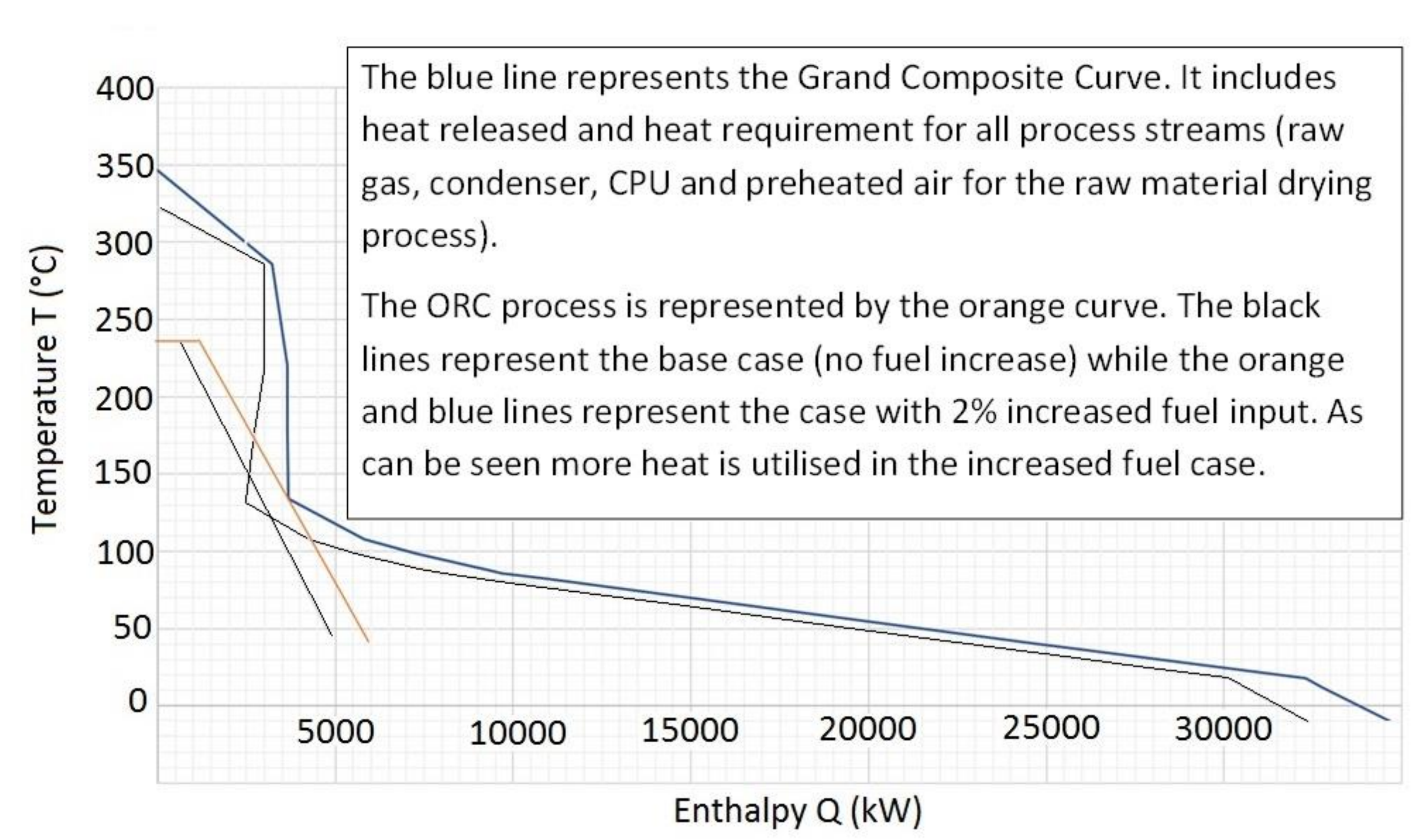


The raw gas CO_2 content fed to the CPU decreases with increasing false air ingress. The CO_2 product purity decreases slightly while the CPU power requirement increases from 167 kWh/t CO_2 to 189 kWh/t CO_2. With an increase in false air ingress of 4%-points, the CPU power requirement increased by 13%.

False air ingress [%]	4%	6%	8%
Feed purity (dry), mol%	88.2	84.3	80.7
CO2 product purity, mol%	97.6	97.5	97.2
CO2 capture ratio, %	90	90	90
CPU power, kWh/t CO2	167	173	189

Energetic optimisation of process by ORC

The electricity output from the ORC increased by 450 kW with an increase in fuel thermal input of 2150 kW. This represents an energetic efficiency of 21%. By comparison the efficiency of a pulverized coal fired power plant is around 40-45% and the efficiency of a typical ORC for the temperature range under consideration is around 10-15%. The optimum fuel feed will be determined, after the final adaptation of the VDZ model to the outcomes of the pilot scale experiments.



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