MHPS

Mitsubishi Hitachi Power Systems

Solutions of Sewage Sludge Mono-Combustion

with an Integrated Rotary Kiln in an Existing Waste-to-Energy Plant

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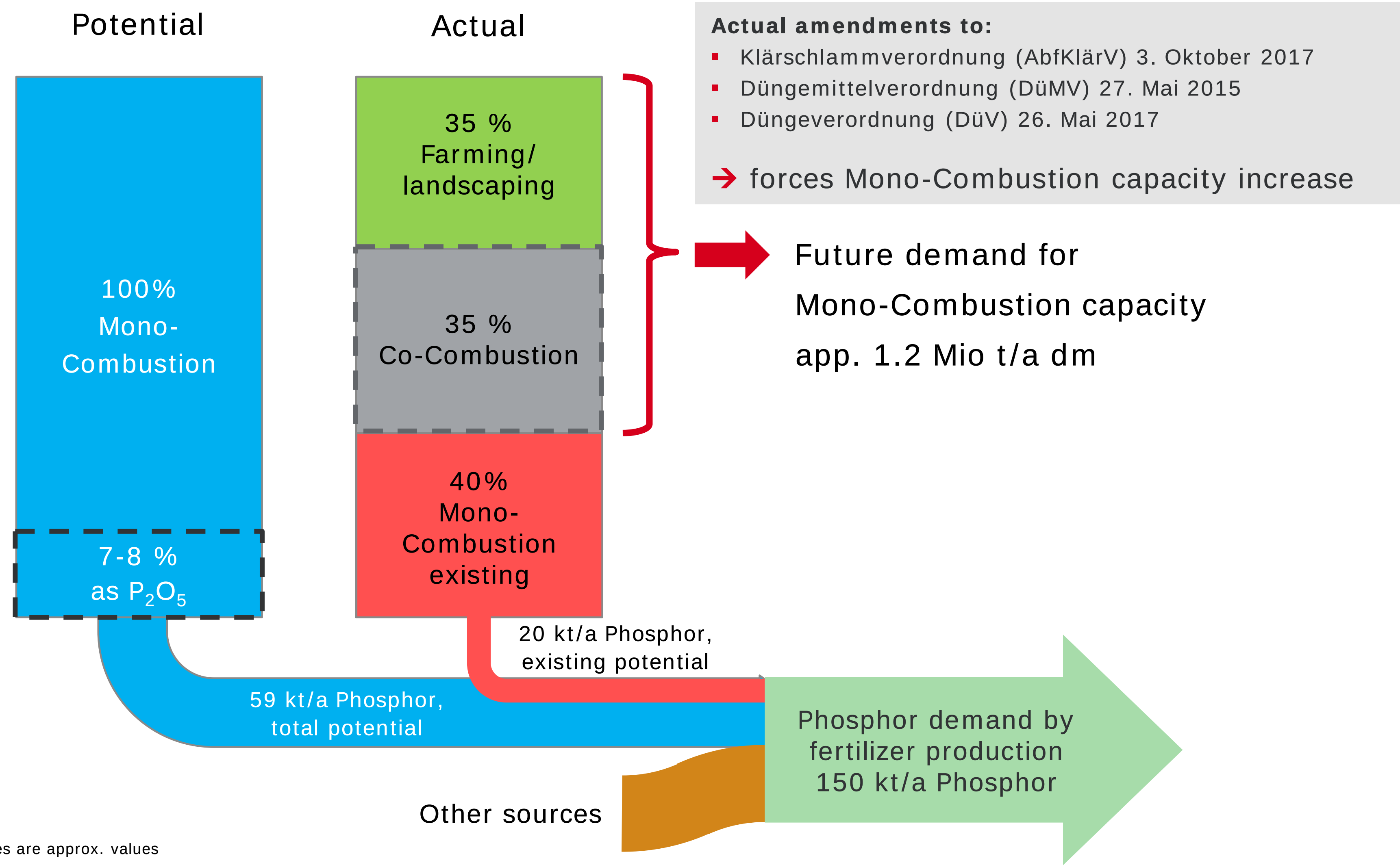
Content

1. Purpose of the system

1,8 Mio t/a dry material sewage sludge in Germany, Phosphor potential



all figures are approx. values

1. Purpose of the system

Sewage sludge Mono Combustion technology

Fluidized Bed

Reference: > 20 plants in operation (Germany)

- Long permit procedures
- Low TOC of ash
- Invest Cost: 100 %

Rotary Kiln (alternative solution)

System connected to (existing) WtE plant using heat of flue-gas and existing AQCS,

Reference: erzo Oftringen plant, in successful operation for 20 years

- Short permit procedures
- Ash-TOC of approx. 10%, to be improved
- Invest Cost: approx. 50%

Actual project

- Implementation of 2 x 40.000 t/a rotary kiln sewage sludge mono-combustion system at Energieversorgung Offenbach AG (EVO)
- With low Total Organic Content in ash (TOC < 5%)

➡ This requires additional measures like optimisation of kiln combustion process. Further TOC reduction by post combustion system is expected.

2. Description of the existing waste to energy plant

Actual:

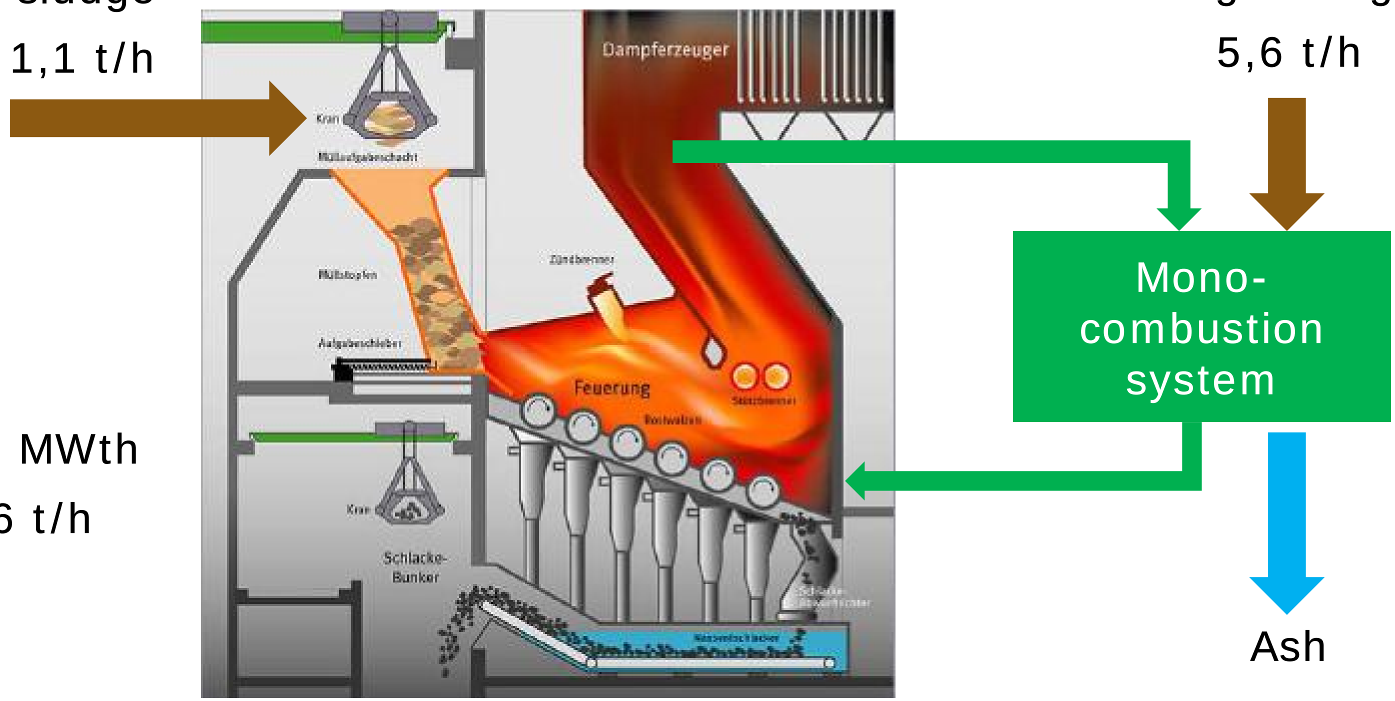
Sewage sludge is co-incinerated at the roller grate combustion.

Planned:

New Mono-Combustion system connected to the existing plant

Sewage sludge

1,1 t/h



Sewage sludge

5,6 t/h

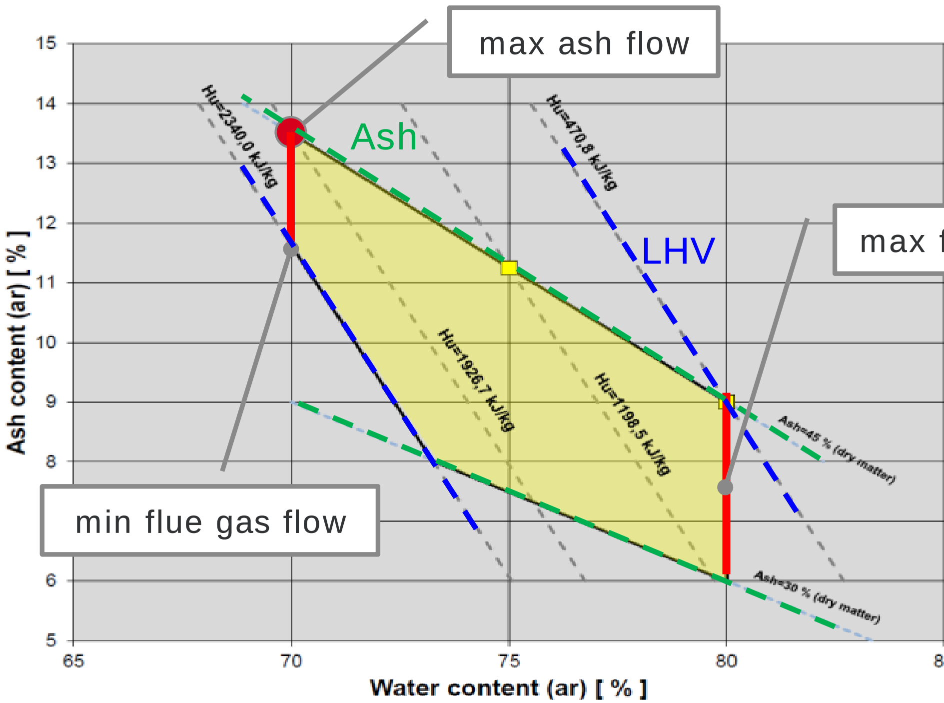
Ash

Firing rate: 28.1 MWth

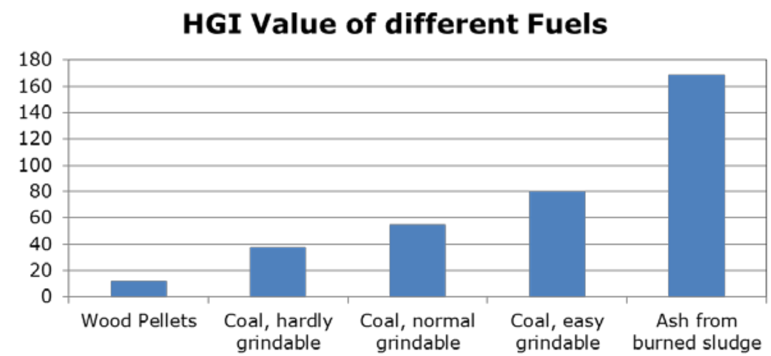
Live steam: 31.6 t/h

Source figure: Bachelorarbeit zur Erlangung des Grades Bachelor of Engineering, Ressourcenschutz in der Abfallwirtschaft – MVA-Aschen als Sekundärrohstoffquelle für Metalle, Tilman Euler

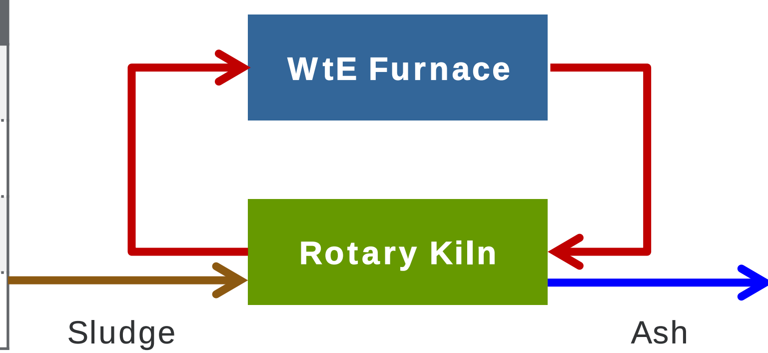
3. Sewage sludge mono combustion



Sludge and ash characteristic



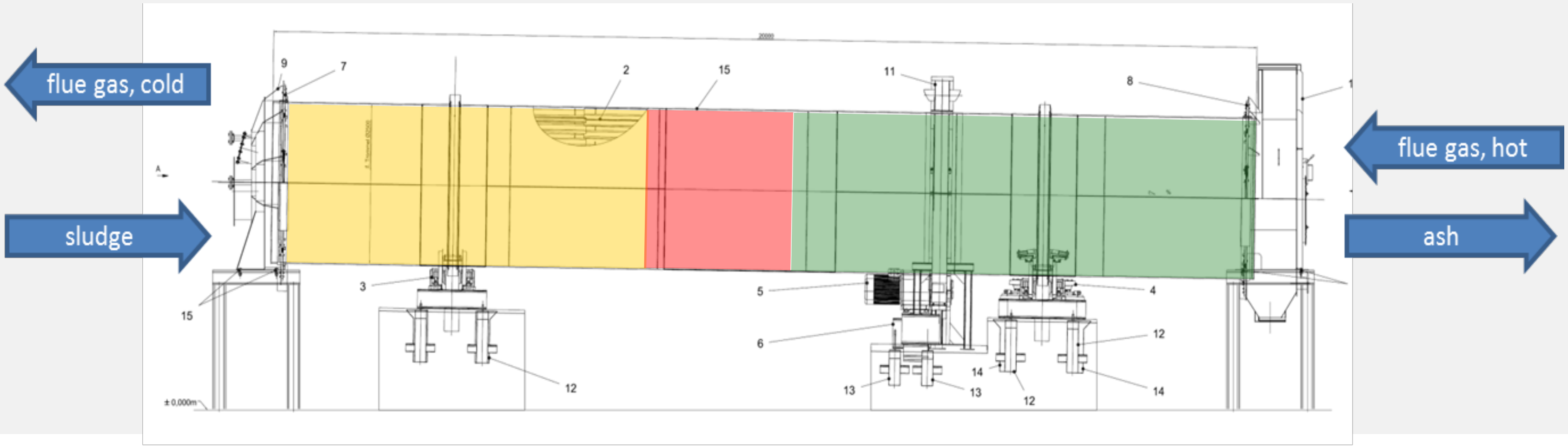
Sludge	Design	Design range
Ash/Inert Material	11,25%	10 – 15%
Water	75,00%	70 – 80%
Dry Material	25,00%	20 – 30%
LHV at 80% Dry Material [MJ/kg]		10 – 12,5



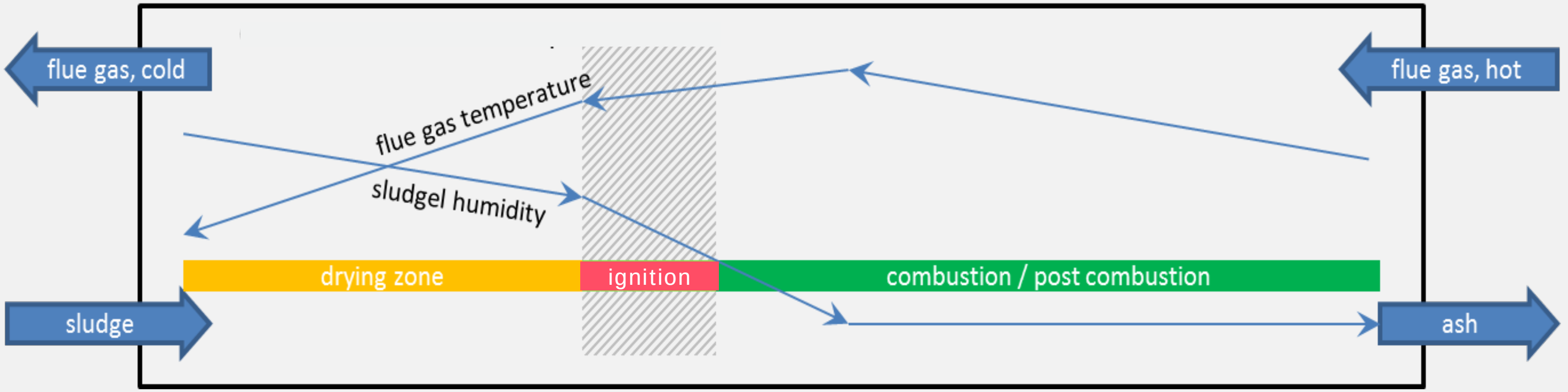
Expected ash properties	Range
TOC [%]	9 – 11
Deformation temperature [°C]	1,120
P_2O_5 [%]	18
Residue 2 mm [%]	37

3. Sewage sludge mono combustion

Rotary kiln drying, combustion and burn out principle process

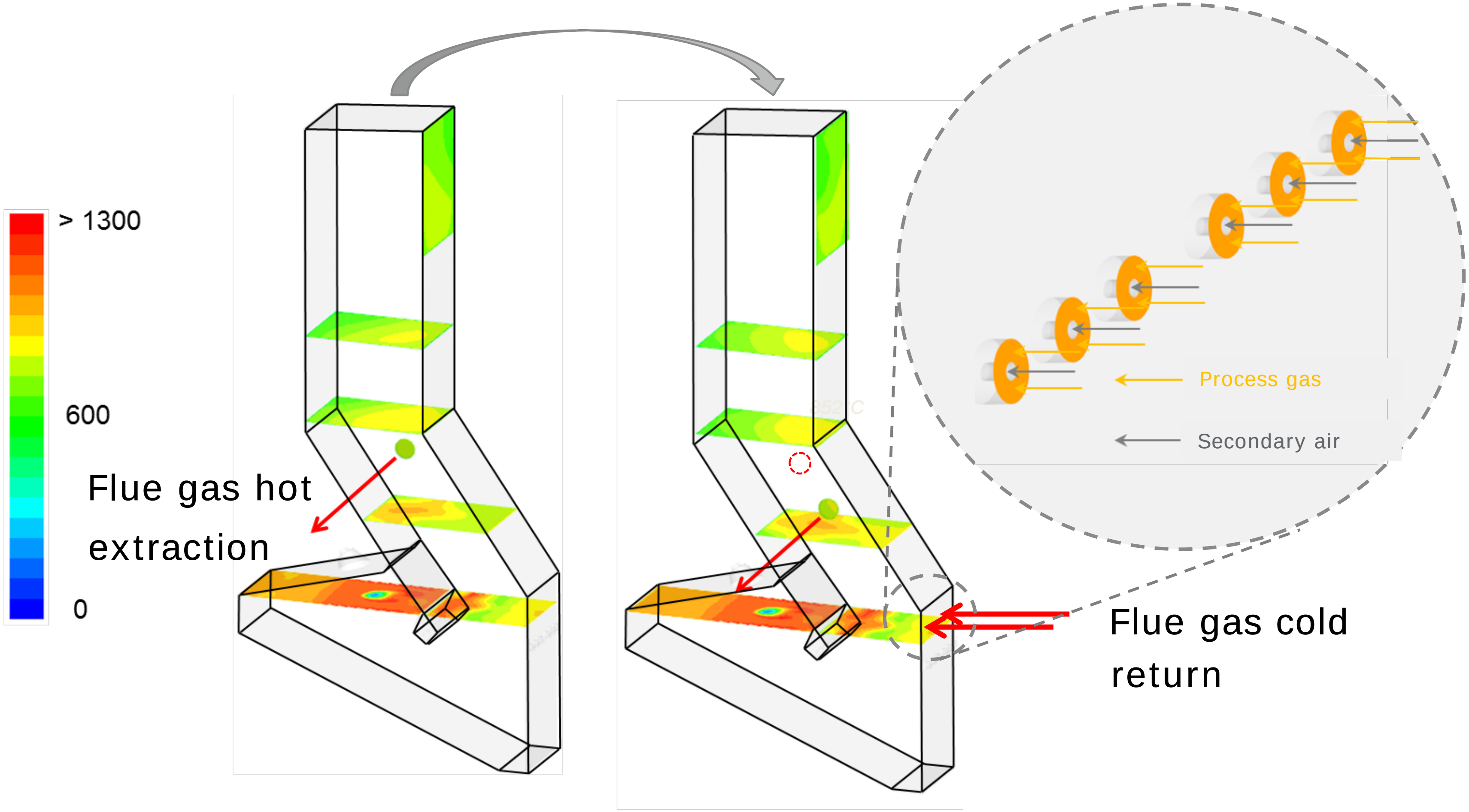


Counter-current combustion process



4. Connection of WtE plant with Rotary Kiln

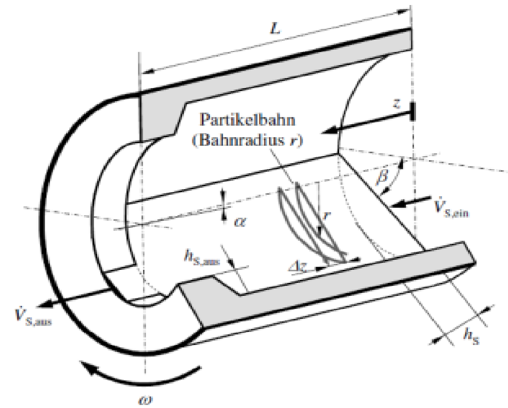
CFD to optimize flue gas extraction and process gas return points



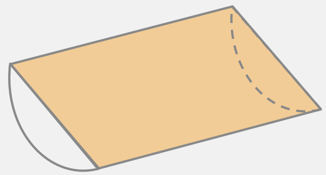
to ensure sufficient combustion conditions in rotary kiln

5. Measures to reduce TOC at burn out zone

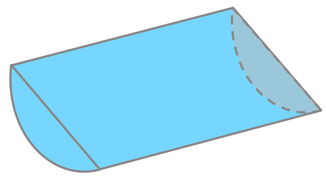
Ash volume flow equation*: $$\dot{V}_S = A_S \cdot v_S = \frac{2}{3}\omega R_i^3 \cdot \left(\frac{\tan\alpha}{\sin\beta} - \frac{\partial h_S}{\partial z}\cot\beta\right) \cdot \left(2\frac{h_S}{R_i} - \frac{h_S^2}{R_i^2}\right)^{\frac{3}{2}}$$



AB: Bed surface = reaction area

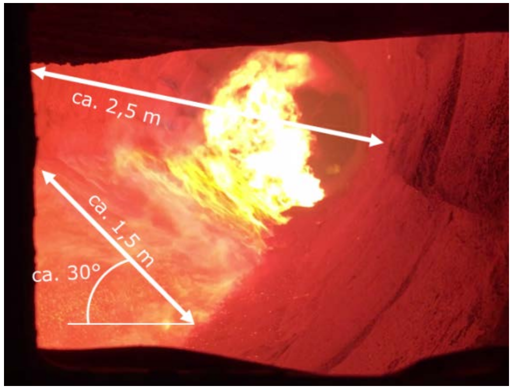


VB: Bed volume



τ: Mean residence time

Reaction number K: $$K = \frac{AB}{VB} * \tau$$

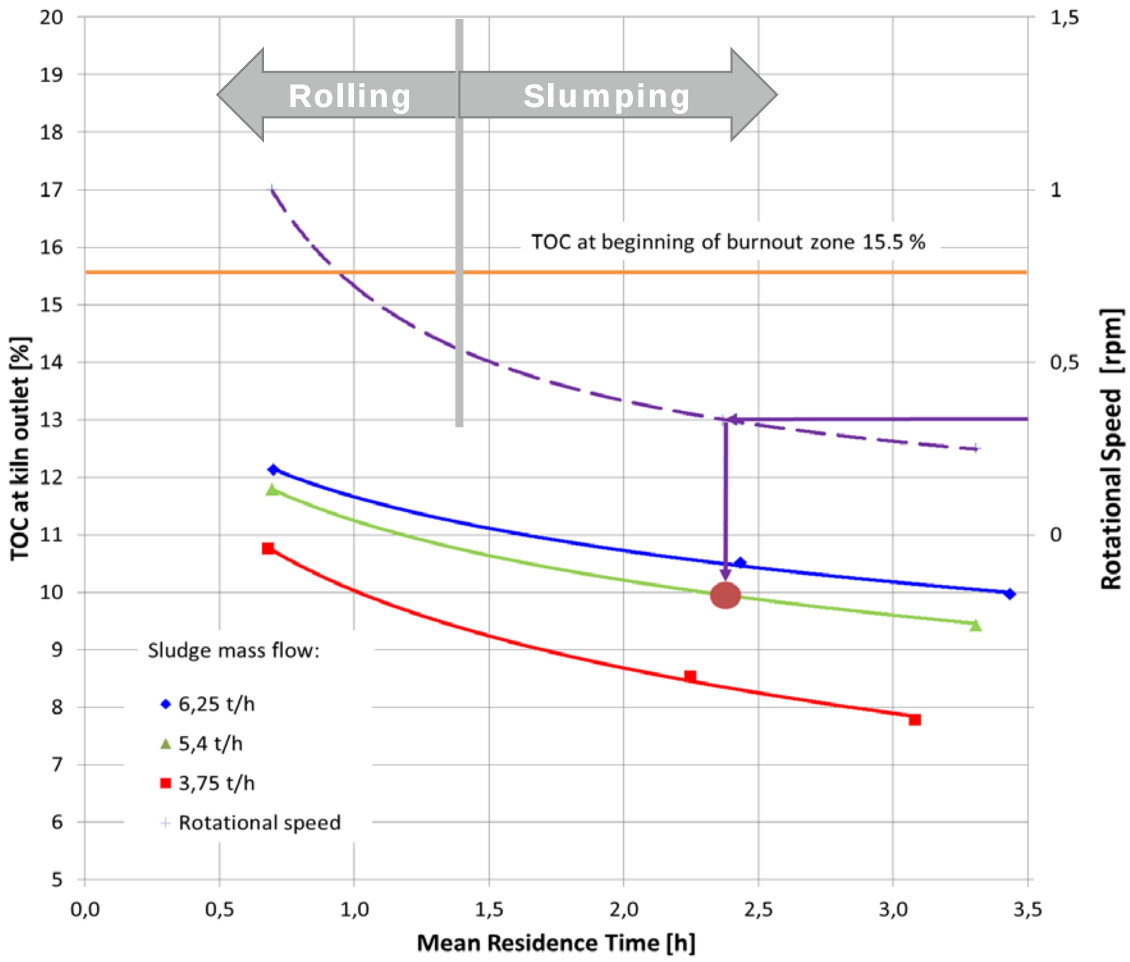


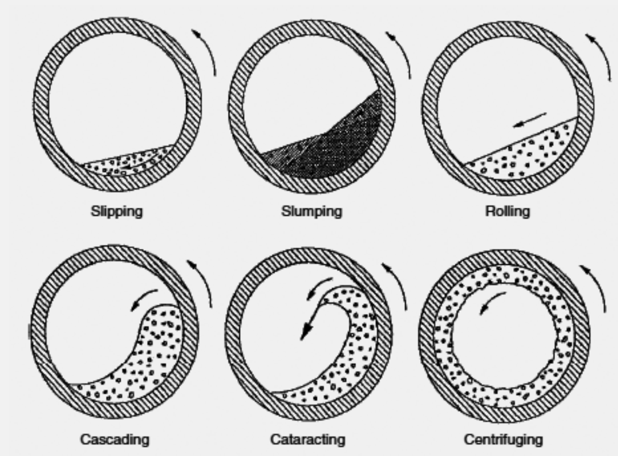
Simplified estimation of TOCω: $$TOC_\omega = TOC_{\alpha,Ref} - \Delta TOC_{Ref} * \frac{K}{K_{Ref}}$$

* Source: Dynamische Modellierung von Drehrohröfen, Dissertation RWTH Aachen, Fakultät für Maschinenwesen, Tobias Ginsberg, 26.11.2010

5. Measures to reduce TOC at burn out zone

Influence of rotational speed to residence time and TOC



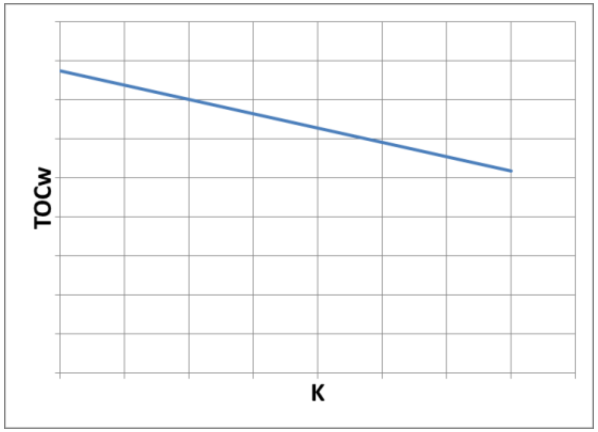


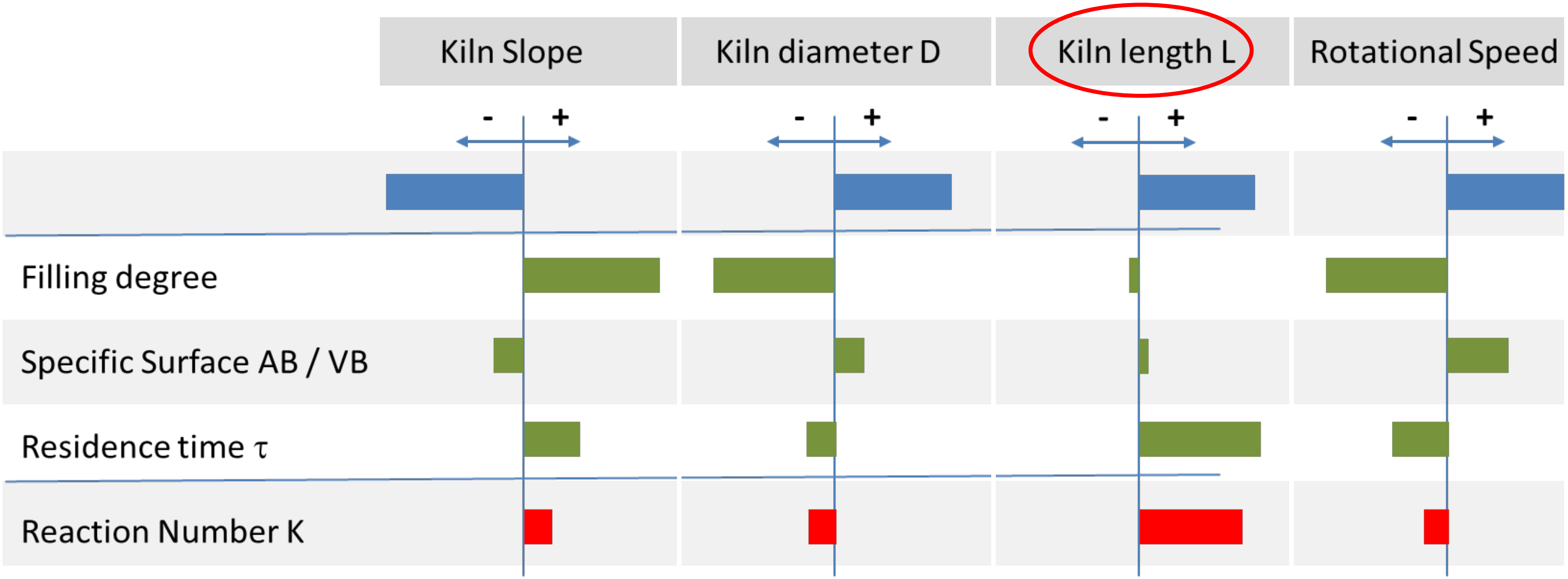
Source Figure: Rotary Kiln, Transport Phenomena and Transport Processes, Akwasi A. Boateng, BH 2008

- Effect of increased residence time by lowering rotational speed is limited
- Throughput influences the TOC

5. Measures to reduce TOC at burn out zone

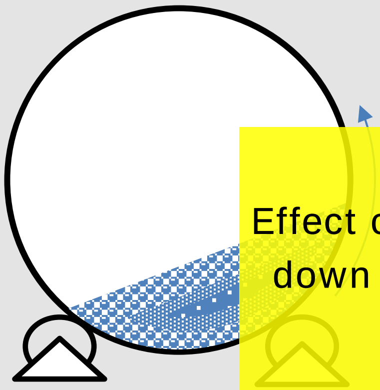
Qualitative influence of various parameters
to reaction number K respectively TOCω,
(at constant ash mass flow)



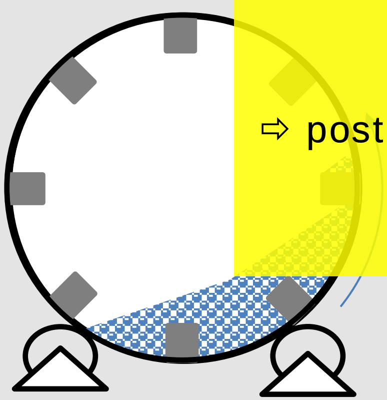


5. Measures to reduce TOC at burn out zone

Segregation

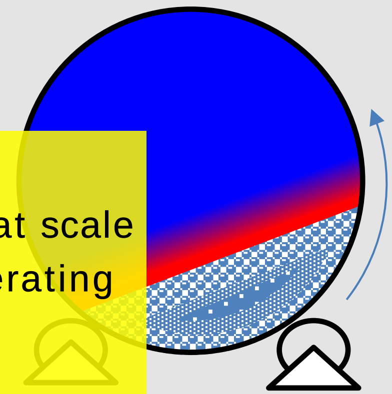


Improve ash mixing by lifter

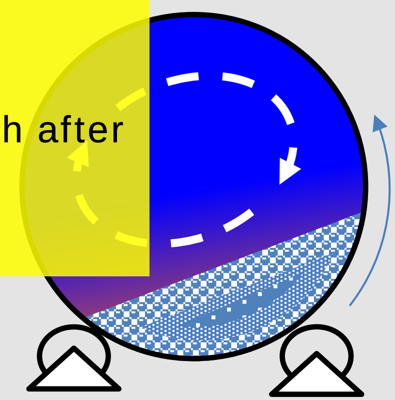


➡ More ash particles get into contact with oxygen atmosphere

Pour oxygen process gas layer



Improve process gas mixing by rotating process gas



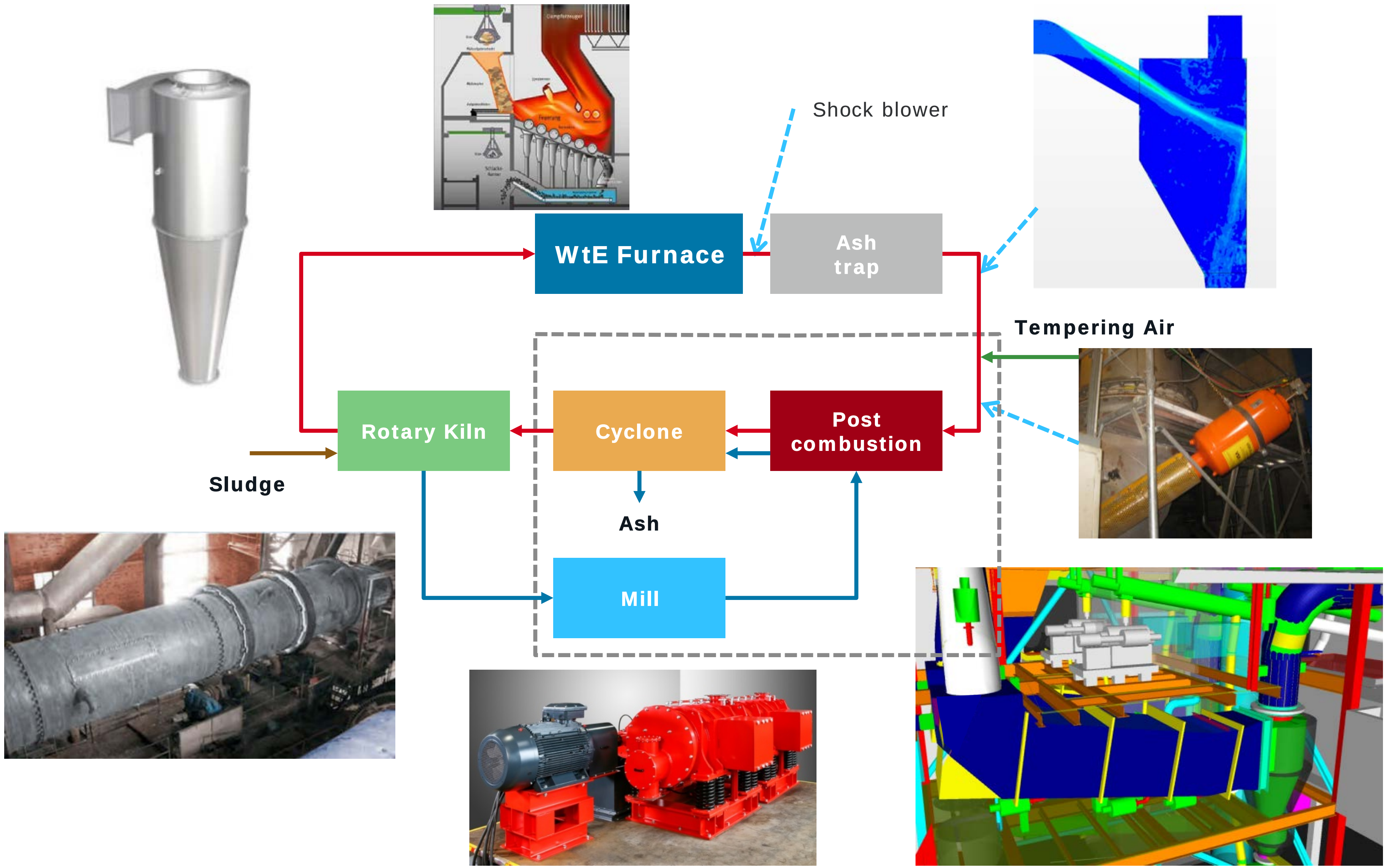
➡ Particles get into contact with oxygen rich atmosphere

Effect can only be proven by tests at scale down kilns or by evaluation of operating data of a running facility.

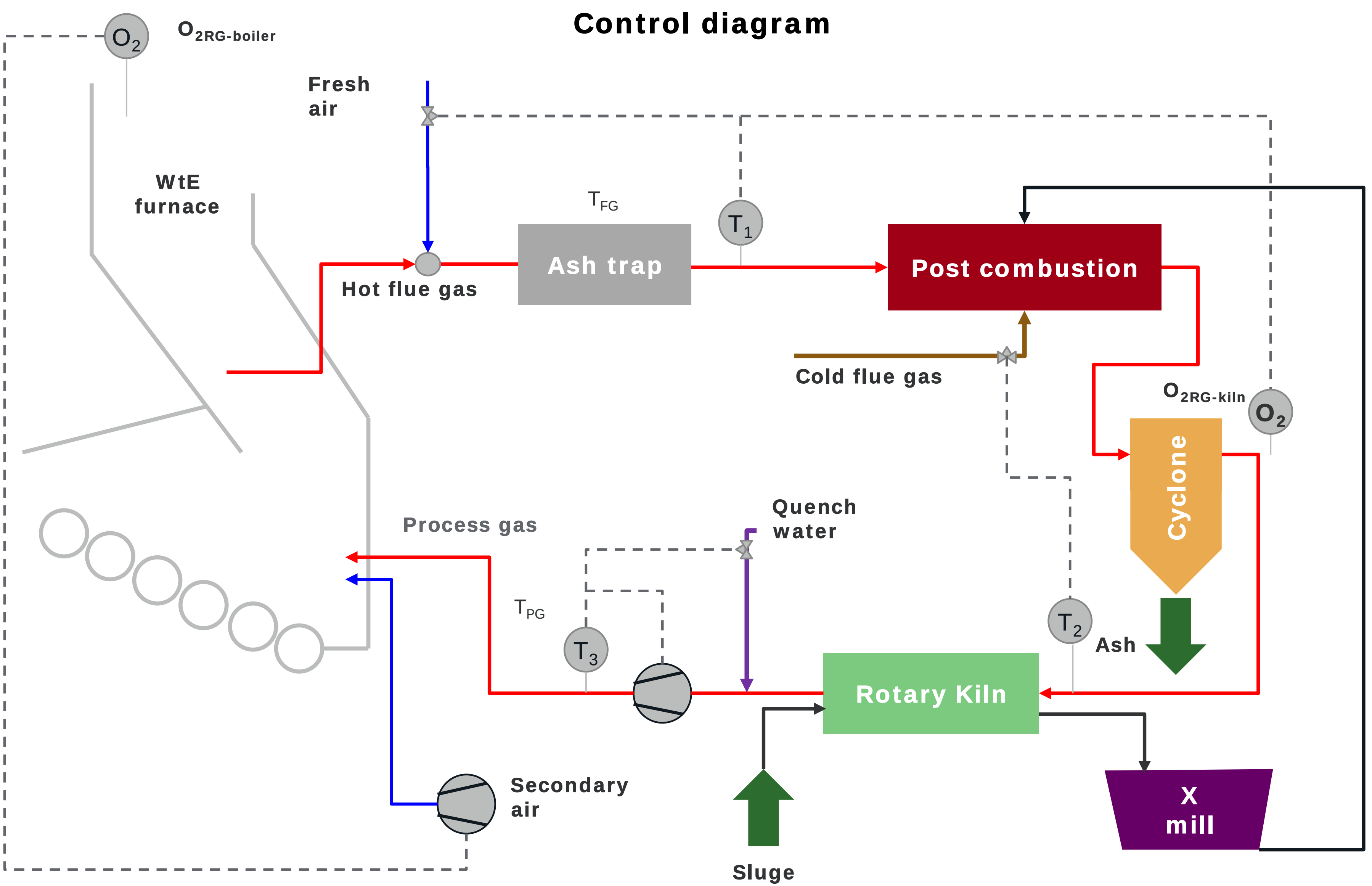
While this is not available additional measures where developed to secure low TOCω content.

⇨ post combustion of carbon in ash after leaving the kiln

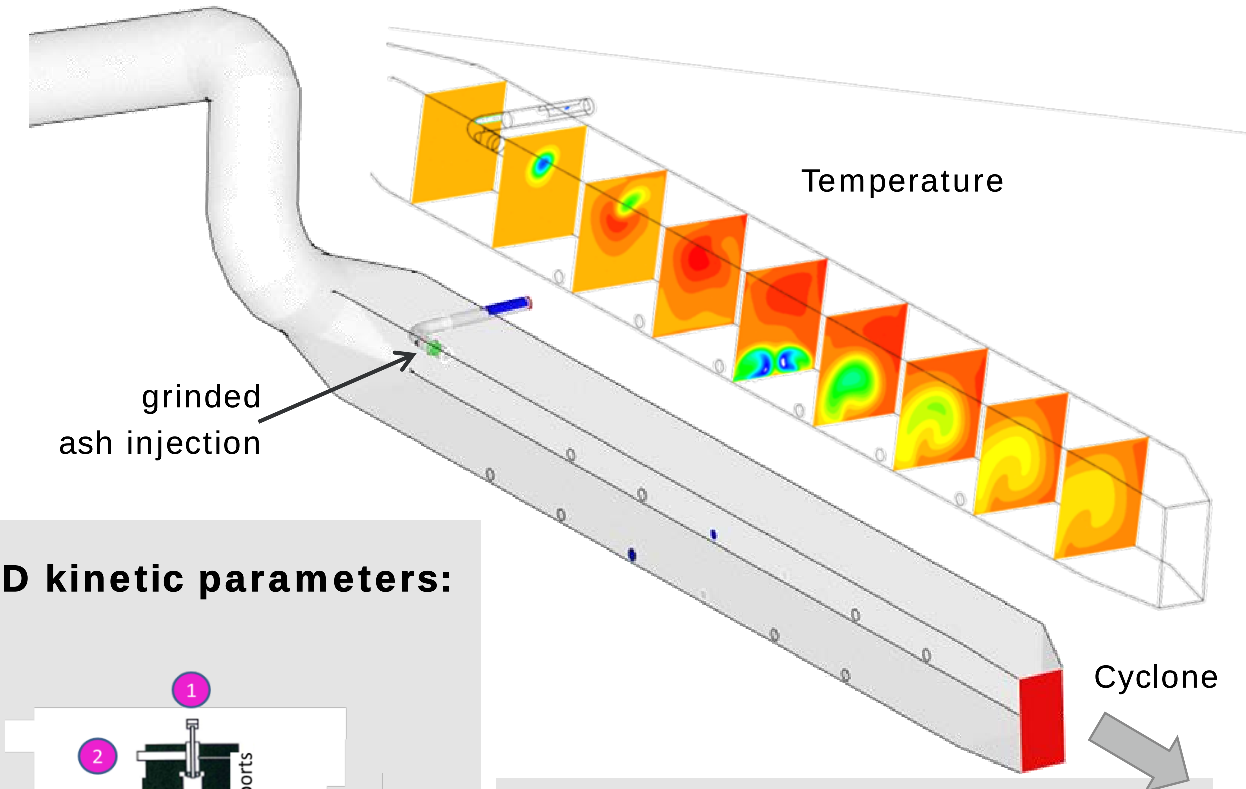
6. Post Combustion system



6. Post combustion system

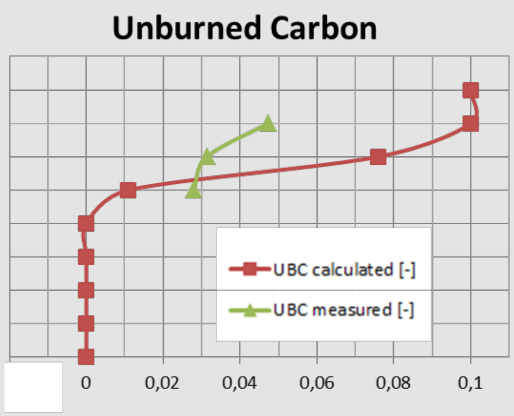


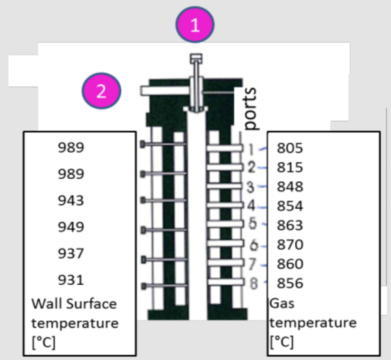
6. Post combustion system



CFD Design of post combustion chamber

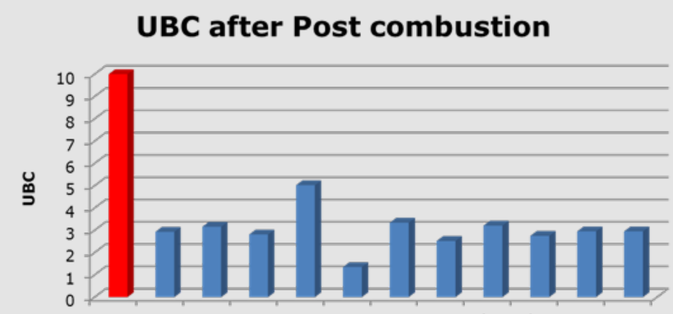
Drop tube tests to check CFD kinetic parameters:





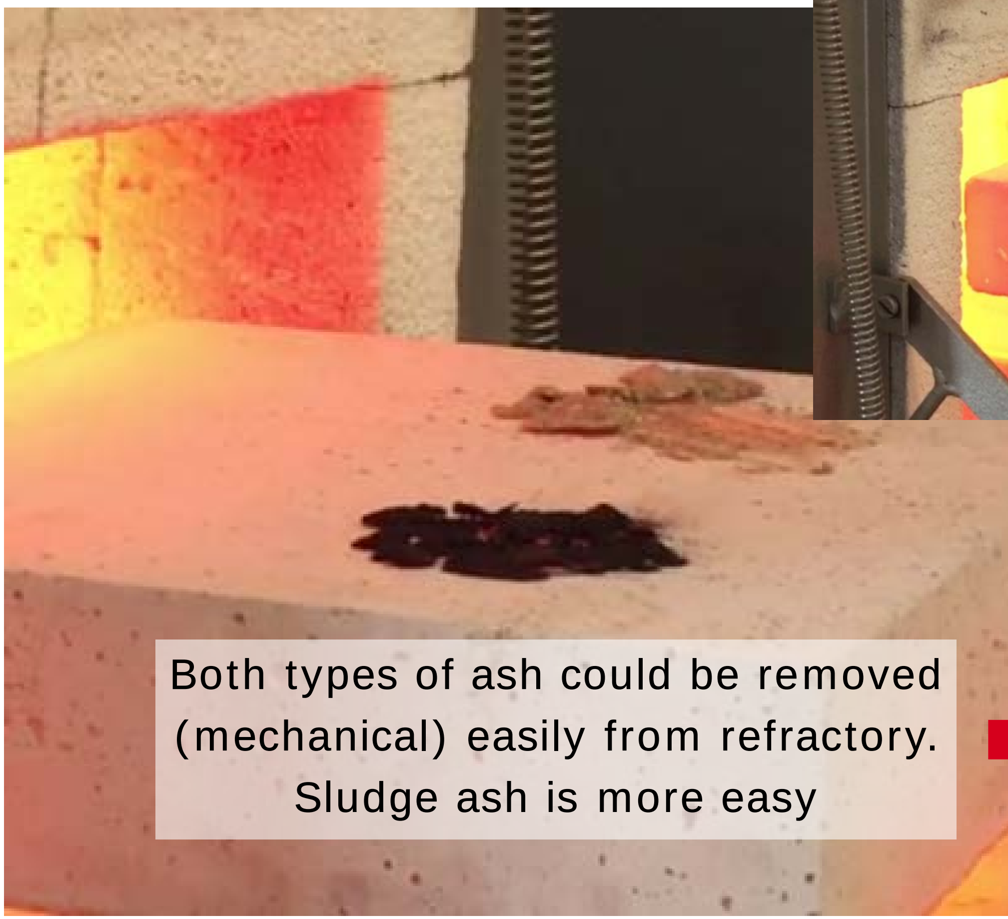
- Burn out is quick enough
- No reduction of Phosphor content in ash was observed

CFD Sensitivity analysis:



6. Post combustion system

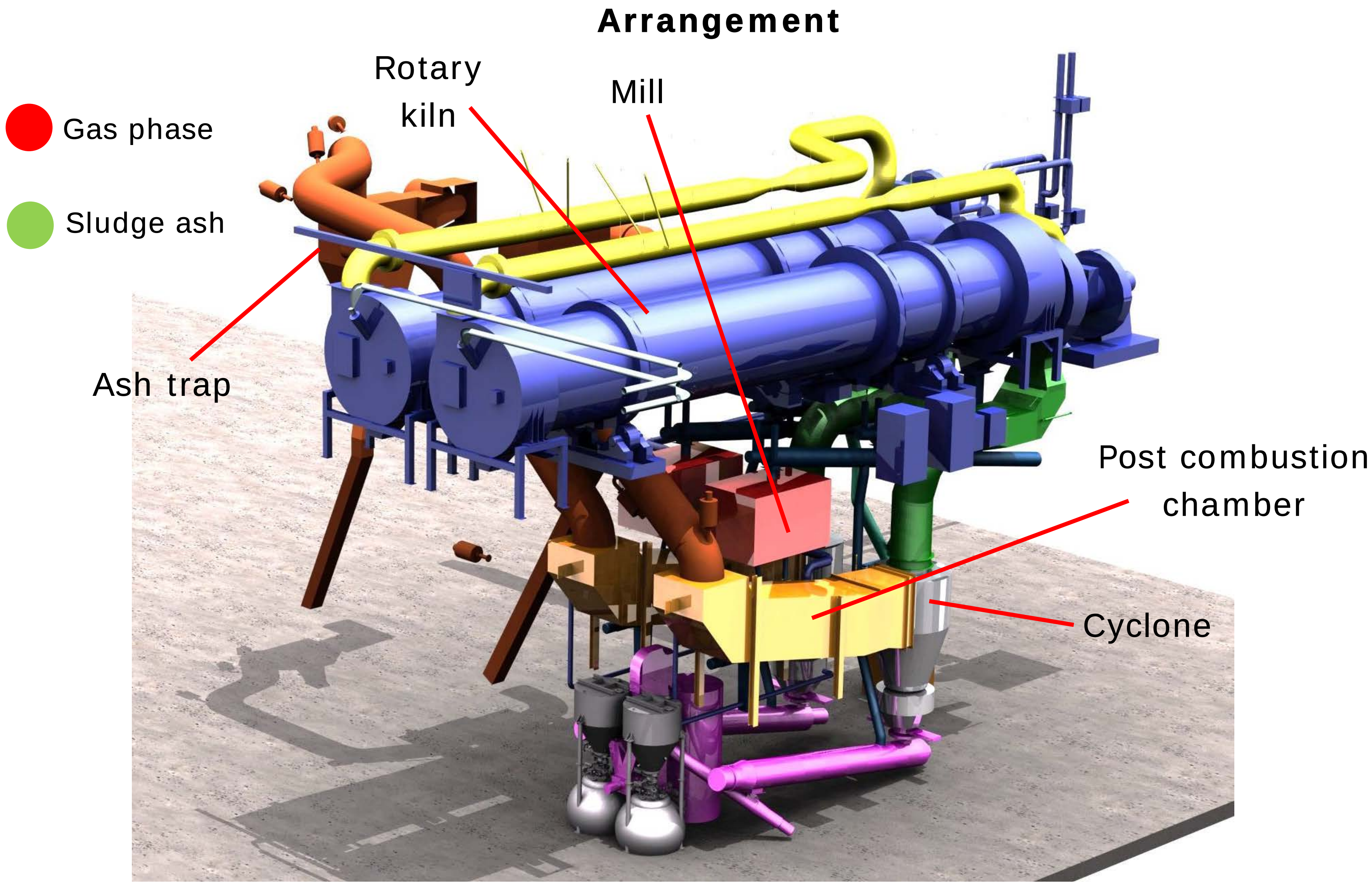
Adhesion tests of waste incineration ash (light) and sludge ash after drop tube tests (dark) at oven temperature 1000°C



Both types of ash could be removed (mechanical) easily from refractory. Sludge ash is more easy

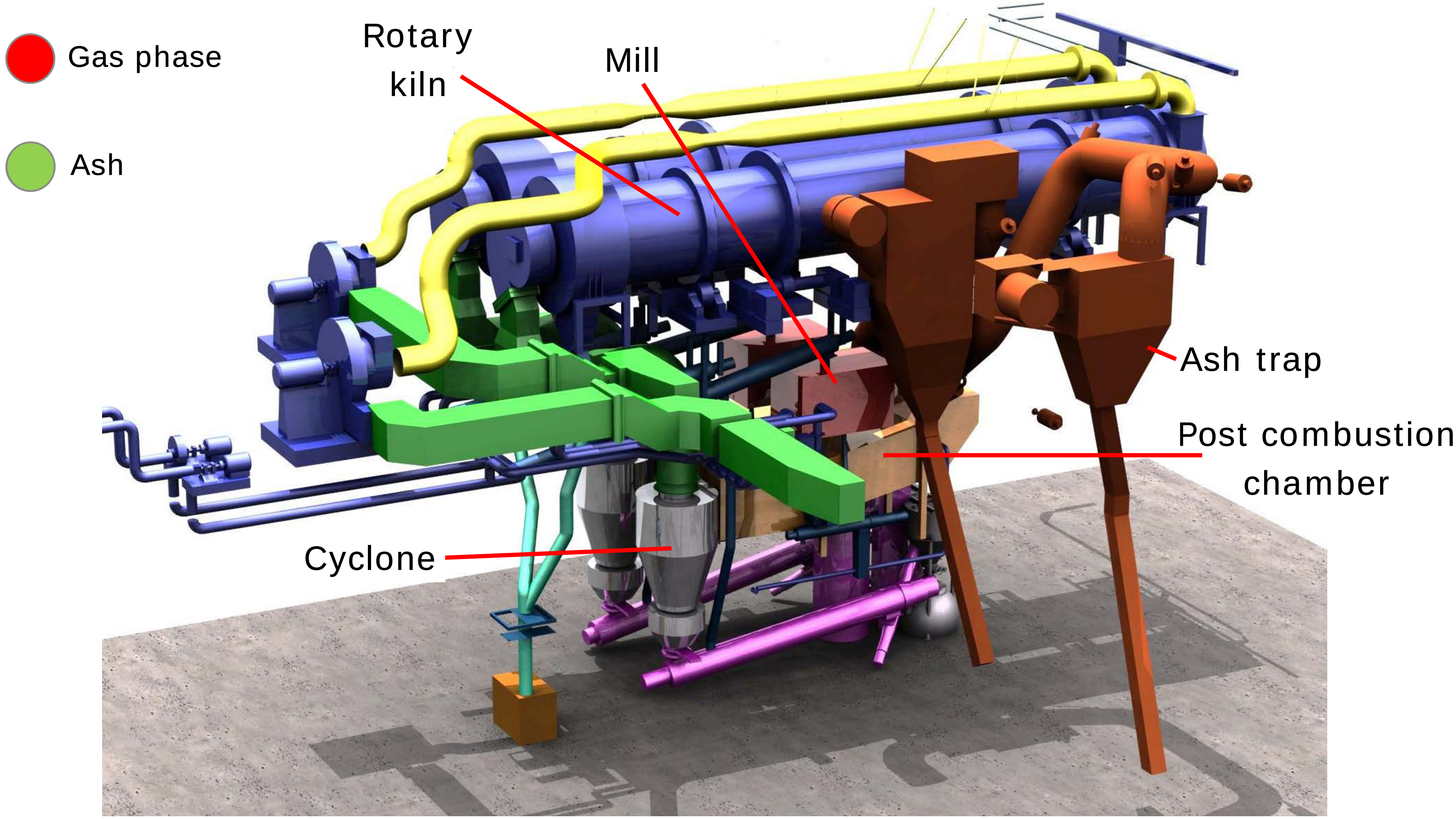
- Ash trap is foreseen to remove incineration ash as early and as much as possible in order to minimize slagging of downstream equipment
- Selection of suitable refractory material for cyclone, combustion chamber and ducts

6. Post combustion system



6. Post combustion system

Arrangement



7. Summary

- The presentation reveals that there are **more opportunities** for plant operators **to treat sewage sludge**. **One** of the **possibilities** to treat sewage sludge is to build a **mono-incineration** plant by using **FB** technology. This includes a long permit procedure as well as high investment costs.

- To avoid such complex effort **alternative solutions** are ready and proven in practice. One of those solutions is to combine a given WtE plant with a **rotary kiln** system by using the flue-gas of the WtE plant. This is practiced in Switzerland (plant erzo Oftringen) and has been in **successful operation for 20 years**.

- However, regulation of sewage sludge treatment and the requirement regarding limit value of **TOC** has to be fulfilled. Currently the **limit value cannot be proven by** only implementing a **rotary kiln** system.

- In order to meet this regulatory requirement MHPSE developed an advanced **upgrade** to the known technology by means of **post-combustion**. CFD calculation and drop tube tests of ash burnout shows very promising results for **lower TOC** content.

- Although it is expected that the **reduction of TOC** could be **improved** by adding **modified blades** and advanced **rotating gas flow** in the burn out area inside the rotary kiln to avoid phenomena like segregation.

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