Thermodynamic behaviour of particles in the flue gas of waste incineration plants

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GKS-Waste-to-Energy Plant

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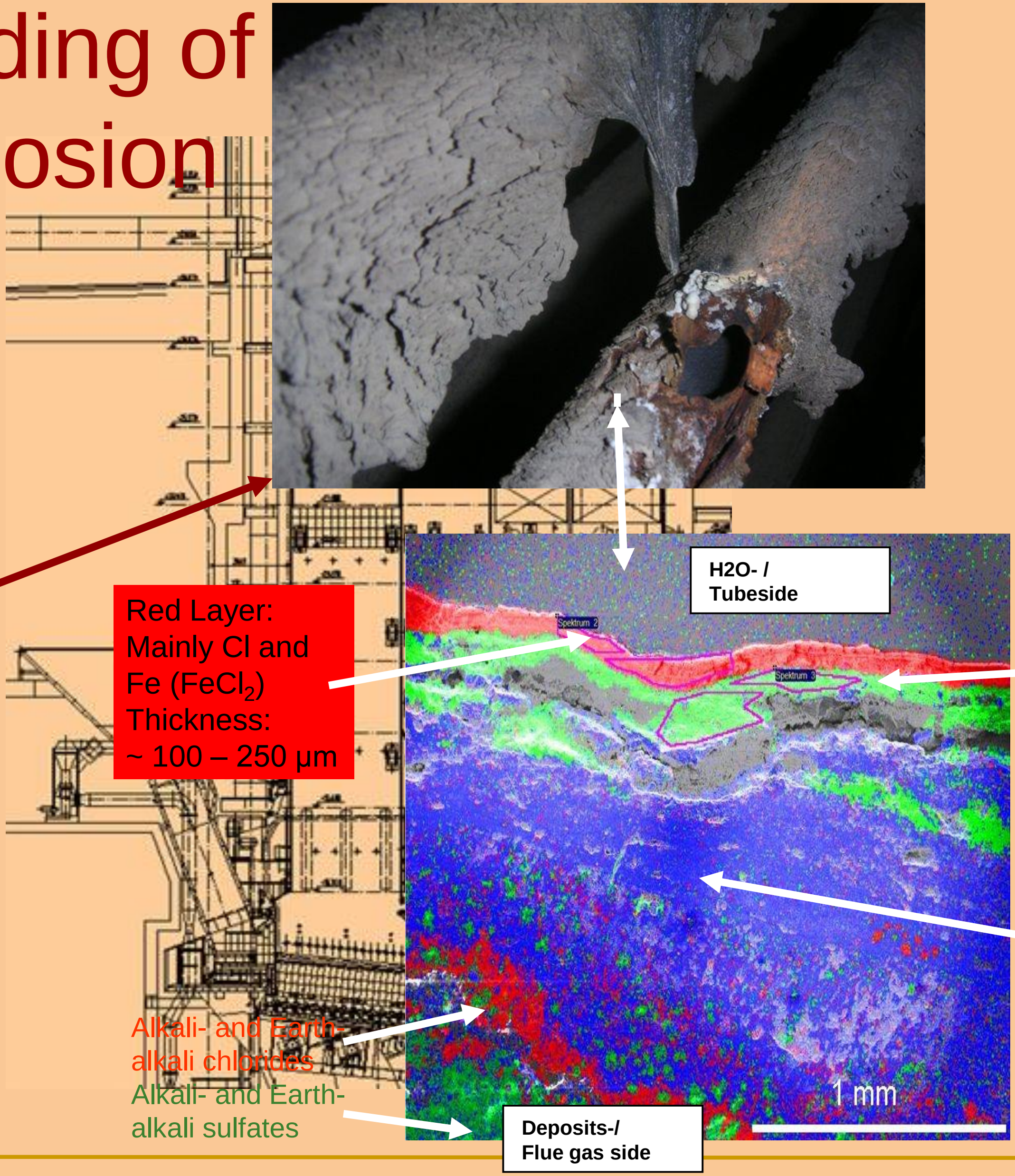
Understanding of HT-Cl-Corrosion



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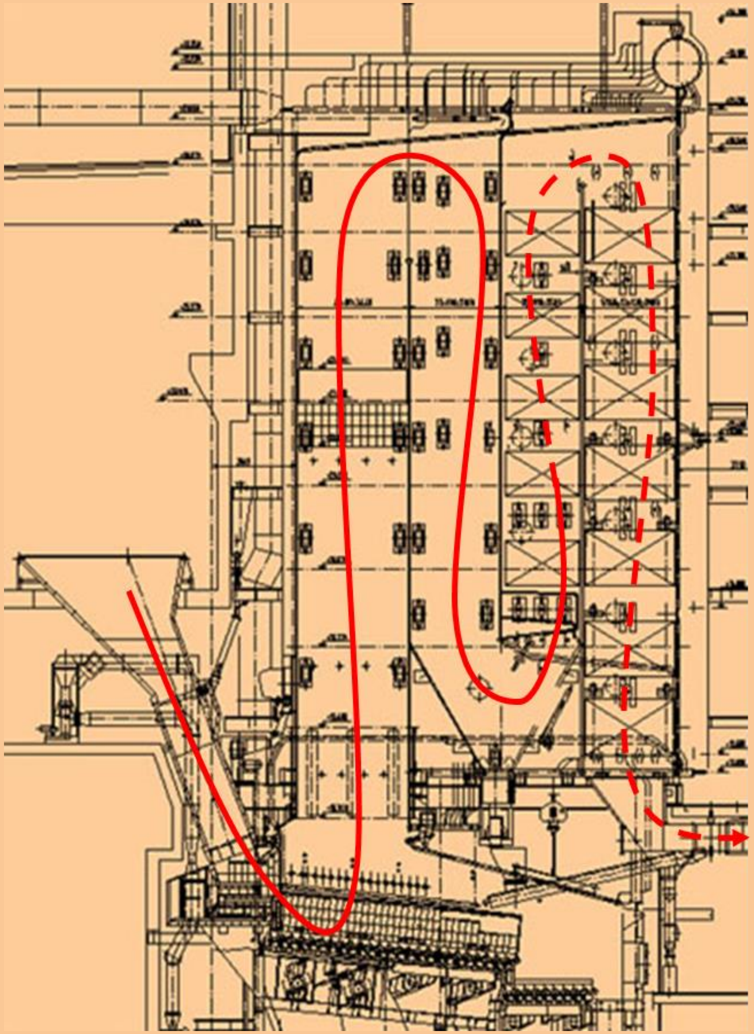
Particles in Boiler



Superheater steam parameter:

Pressure:	65 bars
Temperature:	435 °C

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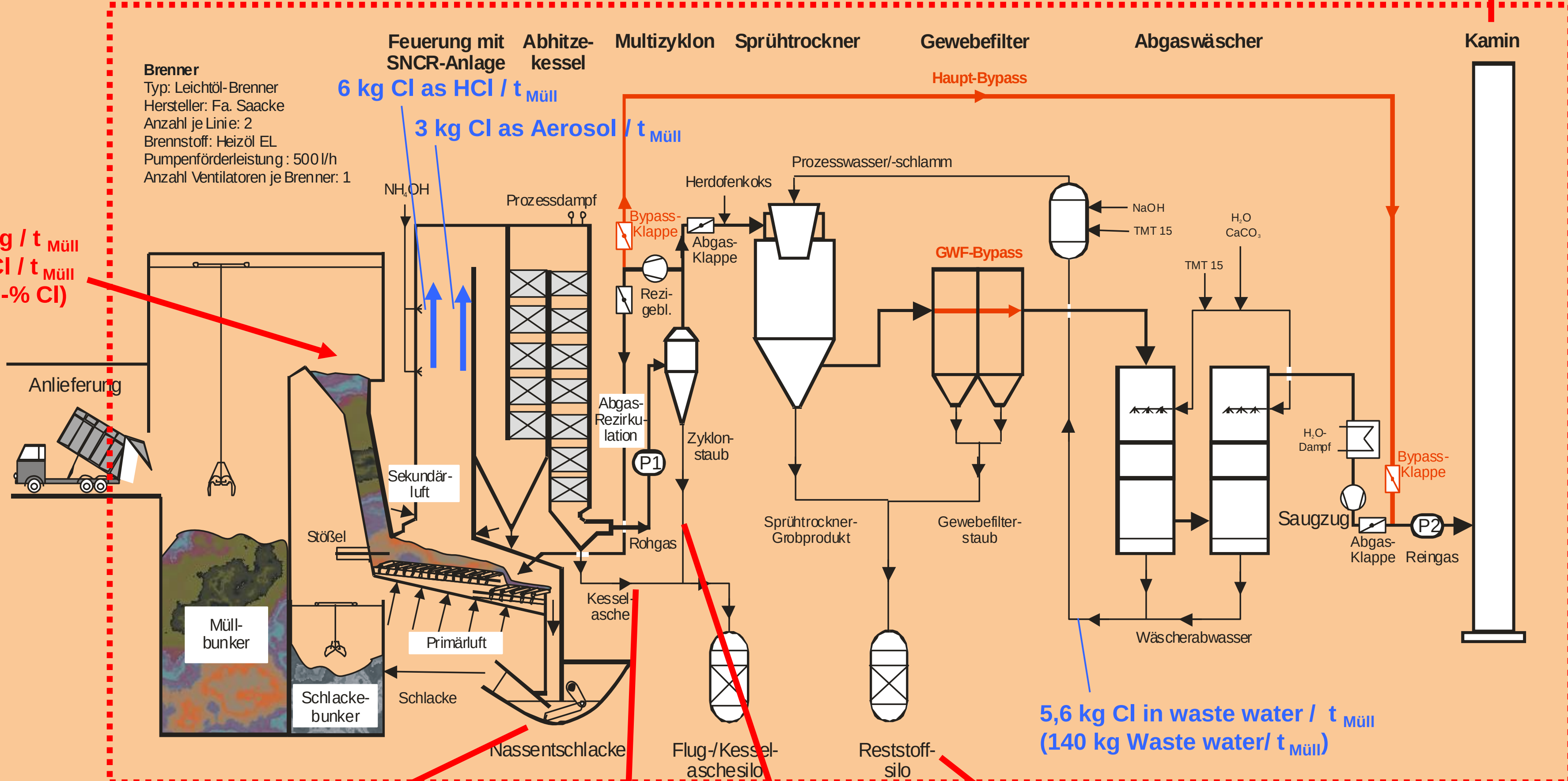
Macro-Chlorine-Balance

(Basedata: 5.000 m_n^3 RG / $t_{Müll}$; 2 g Aerosole / m_n^3)

Clean gas:
6.000 kg / $t_{Müll}$
0,01 kg Cl / $t_{Müll}$
(0,00017 Mas.% Cl)

Fuel:
1.000 kg / $t_{Müll}$
10 kg Cl / $t_{Müll}$
(1 Mas.-% Cl)



Slag:
250 kg / $t_{Müll}$
1 kg Cl / $t_{Müll}$
(0,3-0,55 Mas.-% Cl)

Boiler ash:
7 kg / $t_{Müll}$
0,19 kg Cl / $t_{Müll}$
(2,7 Mas.-% Cl)

Cyclone ash:
7 kg / $t_{Müll}$
0,8 kg Cl / $t_{Müll}$
(11,4 Mas.-% Cl)

Residue:
20 kg / $t_{Müll}$
8 kg Cl / $t_{Müll}$
(40 Mas.-% Cl)

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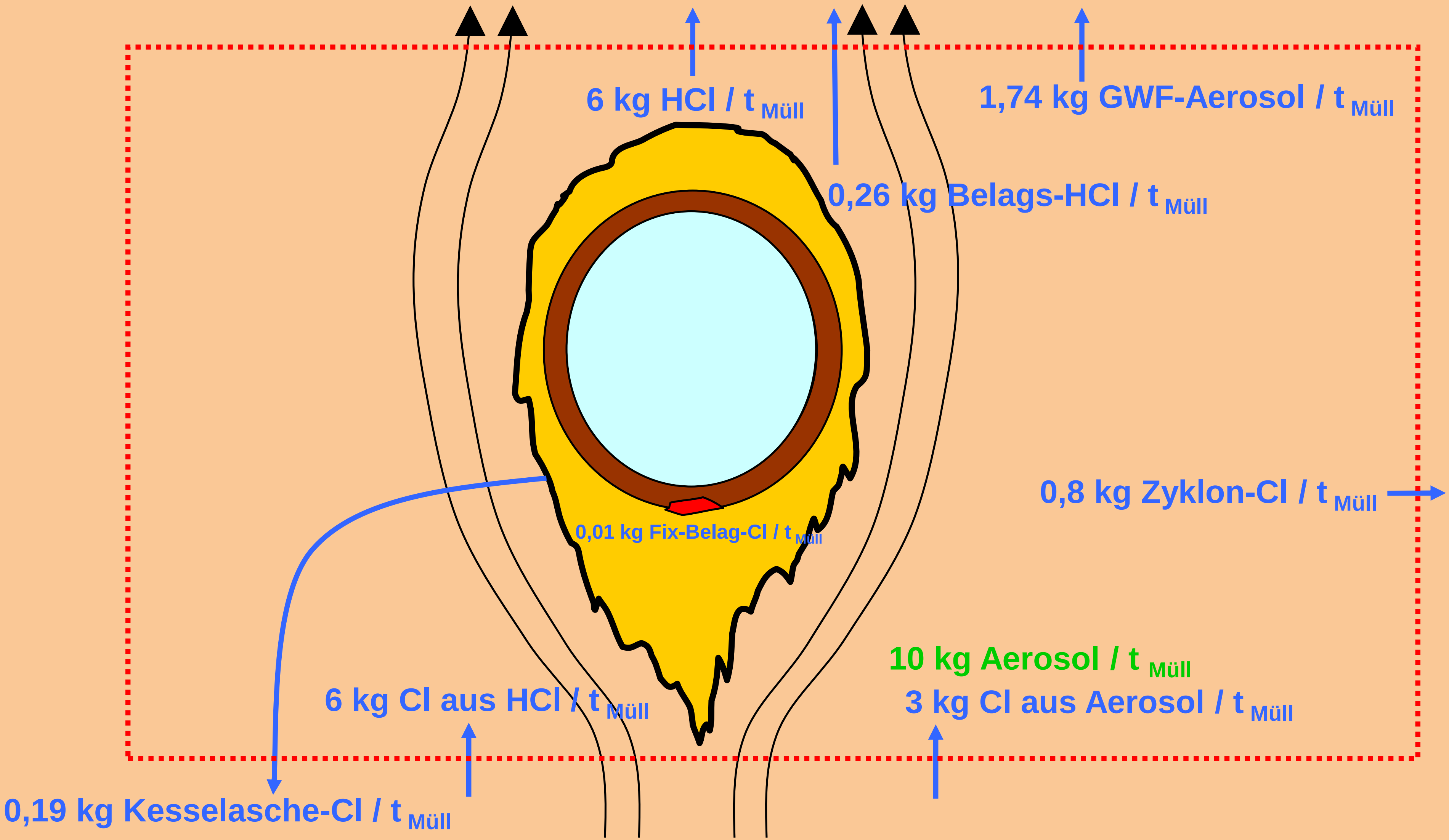
Medio-Chlorine-Balance



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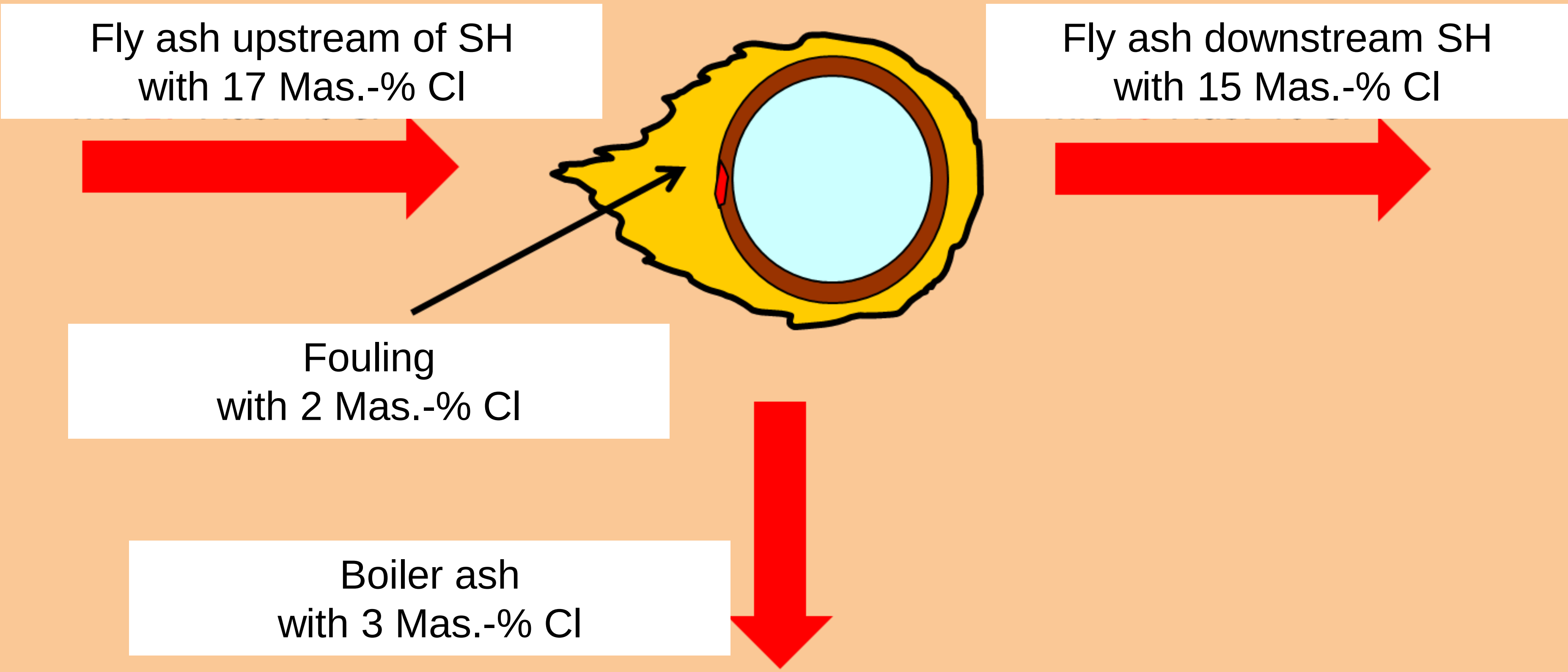
Chlorine Turnover



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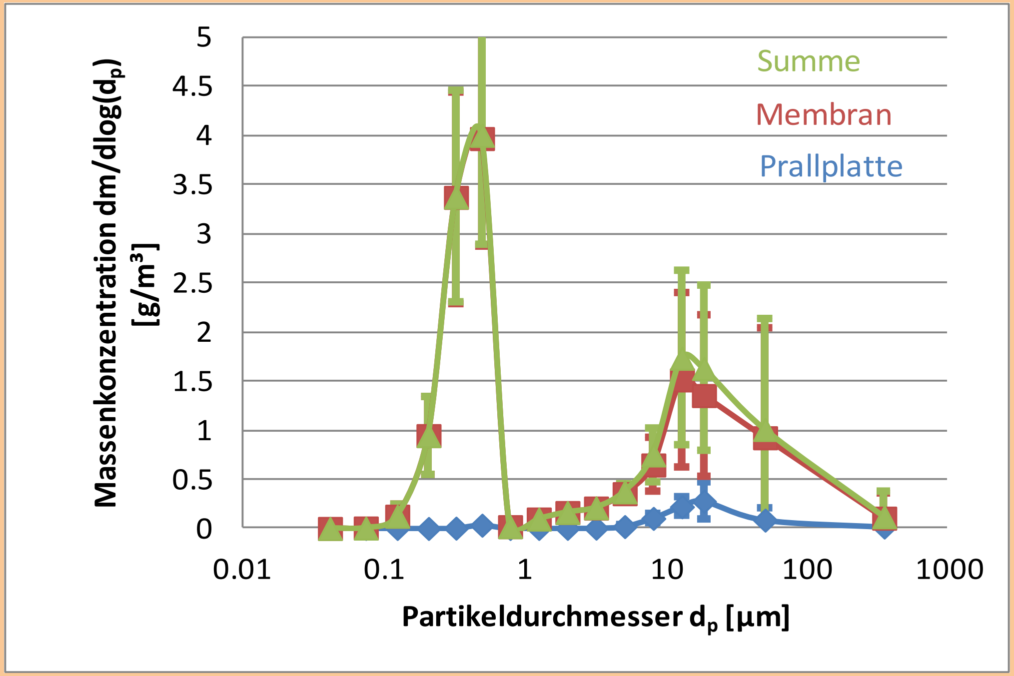
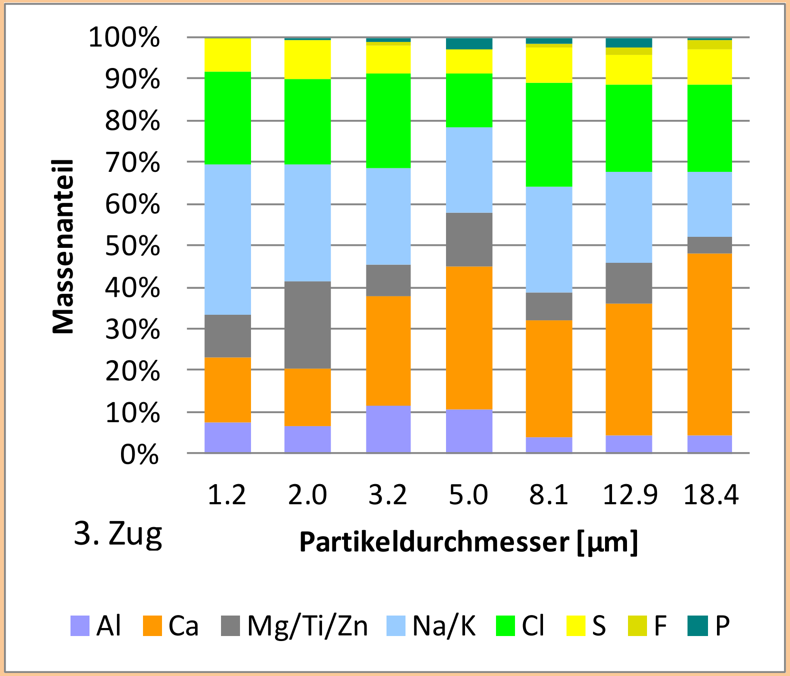
Particle size and consistence





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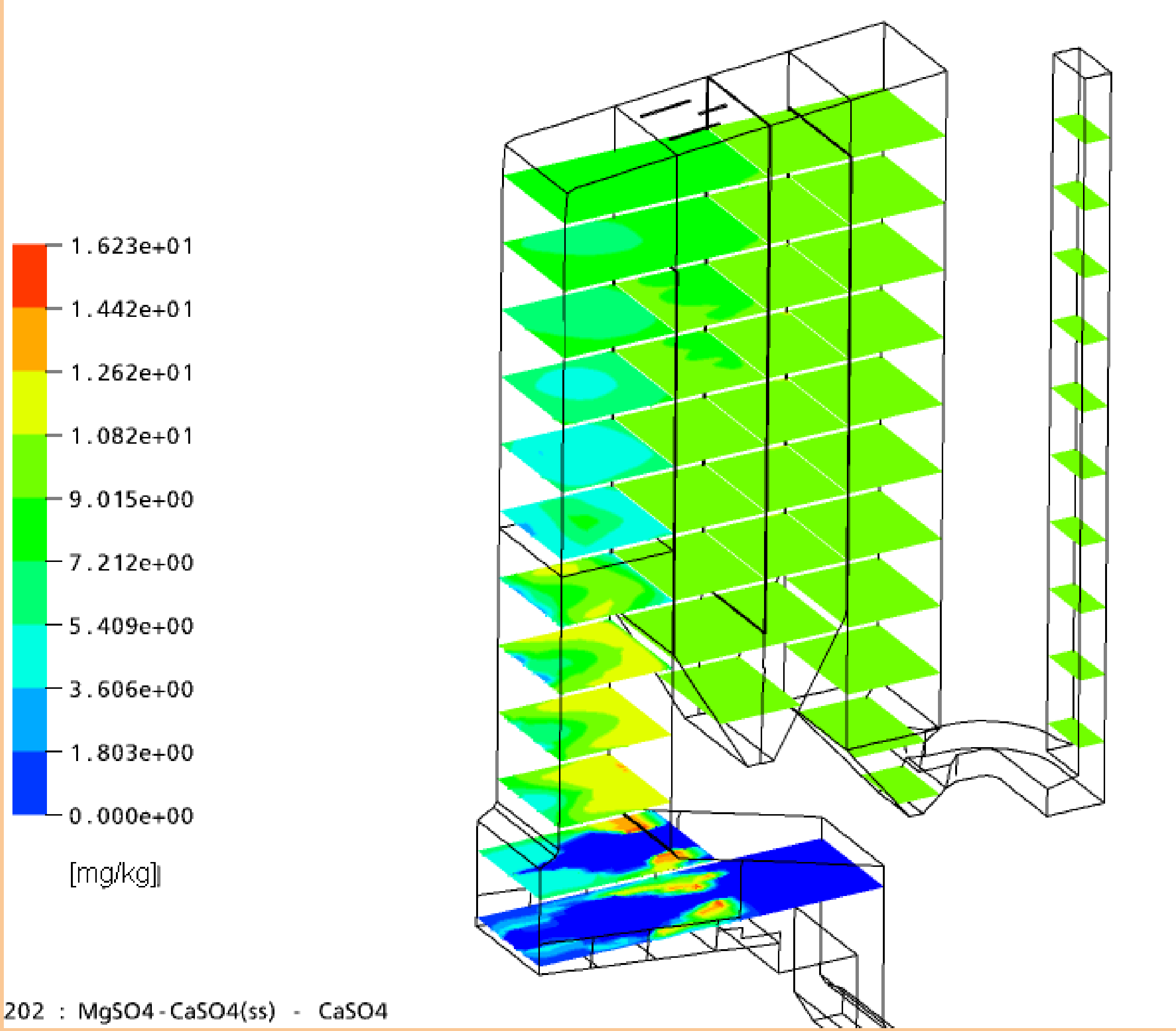
CFD-ChemApp-Coupling

1,500 Species



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Consistence of deposits

	Combustion Chamber (CC)	1st Pass		2nd Pass	Vertical-Boiler		Horizontal-Boiler		
					3rd Pass	4th Pass	3rd Pass	4th Pass	
	Mid of right Sidewall	On Refrac-tory	Above CC	Medium Height	(End-) Super-heater	Eco	Medium Height	(End-) Super-heater	Eco
SiO_2	30,4	18,6	12,2	8,2	6,9	8,7	9,4	6,4	7,9
TiO_2	2,7	2,5	1,6	1,2	1,2	1,3	1,1	0,8	0,6
Al_2O_3	9,6	7,2	5,1	3,5	3,2	3,7	3,2	2,5	2,3
Fe_2O_3	9,8	7,0	4,7	3,4	4,5	4,2	2,4	9,2	2,5
CaO	30,5	29,4	23,9	16,3	24,0	18,1	19,2	17,2	9,6
MgO	2,5	2,2	1,4	1,0	1,2	1,1	1,1	0,8	0,6
K_2O	1,2	3,8	6,0	9,9	7,1	9,6	9,4	8,3	14,8
Na_2O	1,9	3,4	3,6	6,2	4,7	6,3	6,4	6,1	9,8
SO_3	3,1	15,5	22,4	34,4	36,1	29,5	33,9	34,5	35,4
Cl	0,7	1,7	4,8	3,6	2,3	3,9	3,6	5,0	4,0
ZnO	1,4	3,3	3,9	5,8	4,3	6,6	5,4	5,0	6,9
PbO	0,2	0,2	5,8	3,9	1,3	3,0	2,2	2,5	3,5
P_2O_5	3,1	3,1	1,9	1,1	1,3	1,2	0,9	0,8	0,9

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Parameters of Simulation

No. :	Educt-Species:	Amount:	Unit:
			(all in normal conditions)
1	O_2	6 or 0	Vol.-%
2	H_2O	15	Vol.-%
3	CO_2	10	Vol.-%
4	C_3H_8	0 or 3	Vol.-%
5	N_2	Rest	Vol.-%
6	SO_2	0 or 400 or 4.000 or 40.000	mg/m³
7	HCl	1.600	mg/m³
8	Cl_2	0 or 5.000 or 10.000	mg/m³
9	Ca	4.000	mg/m³
10	K	500	mg/m³
11	Na	500	mg/m³
12	Pb	250	mg/m³
13	Zn	250	mg/m³
Sum:	Sum:		

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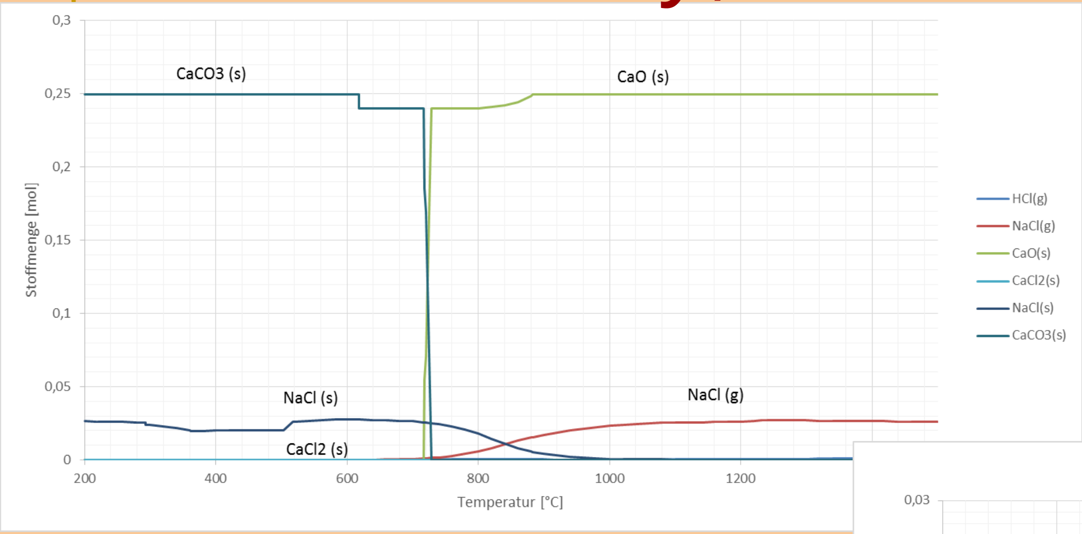
Investigated Cases

Case 1 = oxidising Atmosphere with less Chlor:	Case 1.1:	O_2 = 6 Vol.-%
		C_3H_8 = 0 Vol.-%
		SO_2 = 400 mg/m^3
		Cl_2 = 0 mg/m^3
	Case 1.2:	O_2 = 6 Vol.-%
		C_3H_8 = 0 Vol.-%
		SO_2 = 0 mg/m^3
		Cl_2 = 0 mg/m^3
Case 2 = reducing Atmosphere with less Chlor:	Case 2.1:	O_2 = 0 Vol.-%
		C_3H_8 = 3 Vol.-%
		SO_2 = 400 mg/m^3
		Cl_2 = 0 mg/m^3
	Case 2.2:	O_2 = 0 Vol.-%
		C_3H_8 = 3 Vol.-%
		SO_2 = 0 mg/m^3
		Cl_2 = 0 mg/m^3
Case 3 = oxidising Atmosphere with medium amount of Chlor:	Case 3.1:	O_2 = 6 Vol.-%
		C_3H_8 = 0 Vol.-%
		SO_2 = 400 mg/m^3
		Cl_2 = 5.000 mg/m^3
	Case 3.2:	O_2 = 6 Vol.-%
		C_3H_8 = 0 Vol.-%
		SO_2 = 0 mg/m^3
		Cl_2 = 5.000 mg/m^3
Case 4 = reducing Atmosphere with medium amount of Chlor:	Case 4.1:	O_2 = 0 Vol.-%
		C_3H_8 = 3 Vol.-%
		SO_2 = 400 mg/m^3
		Cl_2 = 5.000 mg/m^3
	Case 4.2:	O_2 = 0 Vol.-%
		C_3H_8 = 3 Vol.-%
		SO_2 = 0 mg/m^3
		Cl_2 = 5.000 mg/m^3

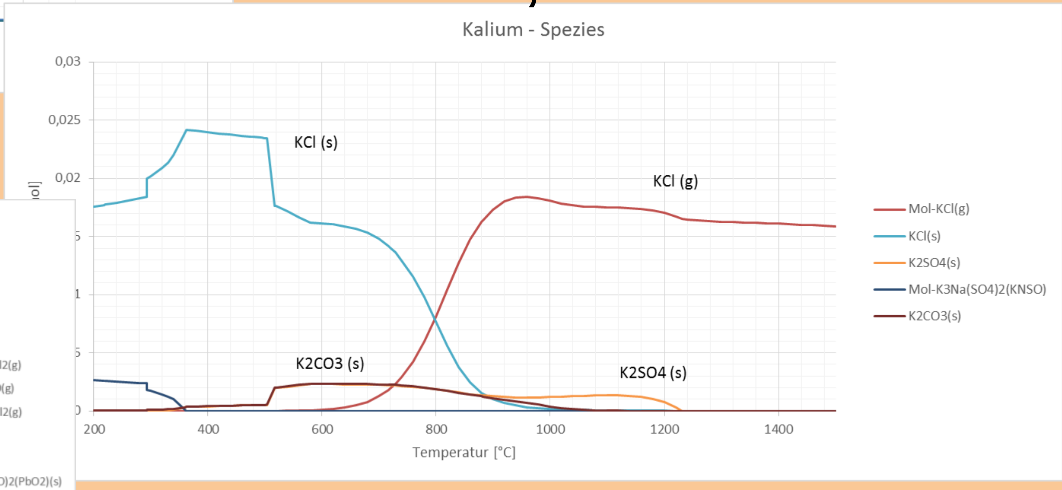
Case 5 = oxidising Atmosphere with high amount of Chlor:	Case 5.1:	O_2 = 6 Vol.-%
		C_3H_8 = 0 Vol.-%
		SO_2 = 400 mg/m^3
		Cl_2 = 10.000 mg/m^3
	Case 5.2:	O_2 = 6 Vol.-%
		C_3H_8 = 0 Vol.-%
		SO_2 = 0 mg/m^3
		Cl_2 = 10.000 mg/m^3
Case 6 = reducing Atmosphere with high amount of Chlor:	Case 6.1:	O_2 = 0 Vol.-%
		C_3H_8 = 3 Vol.-%
		SO_2 = 400 mg/m^3
		Cl_2 = 10.000 mg/m^3
	Case 6.2:	O_2 = 0 Vol.-%
		C_3H_8 = 3 Vol.-%
		SO_2 = 0 mg/m^3
		Cl_2 = 10.000 mg/m^3
Case 7 = oxidising Atmosphere with medium amount of Chlor und high amount of Schwefel:	**Case 7.1 (with high amount of SO2):**	**O_2 = 6 Vol.-%**
		C_3H_8 = 0 Vol.-%
		SO_2 = 4.000 mg/m^3
		Cl_2 = 5.000 mg/m^3
	Case 7.2 (with very high amount of SO2):	**O_2 = 6 Vol.-%**
		C_3H_8 = 0 Vol.-%
		SO_2 = 40.000 mg/m^3
		Cl_2 = 5.000 mg/m^3
Case 8 = reducing Atmosphere with medium amount of Chlor and high amount of Schwefel:	**Case 8.1 (with high amount of SO2):**	**O_2 = 0 Vol.-%**
		C_3H_8 = 3 Vol.-%
		SO_2 = 4.000 mg/m^3
		Cl_2 = 5.000 mg/m^3
	Case 8.2 (with very high amount of SO2):	**O_2 = 0 Vol.-%**
		C_3H_8 = 3 Vol.-%
		SO_2 = 40.000 mg/m^3
		Cl_2 = 5.000 mg/m^3

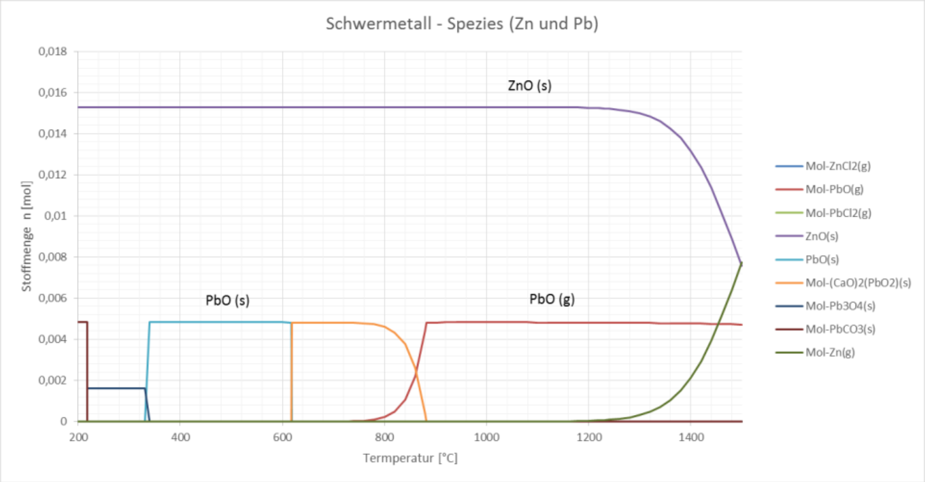
Oxi.: HCl only, no additional Cl (Case 1)



HCl “absorbed“ by Na and K less by Ca
S “absorbed” by K at first

CaO formation at 700 °C
KClg ; PbClg at 850 °C





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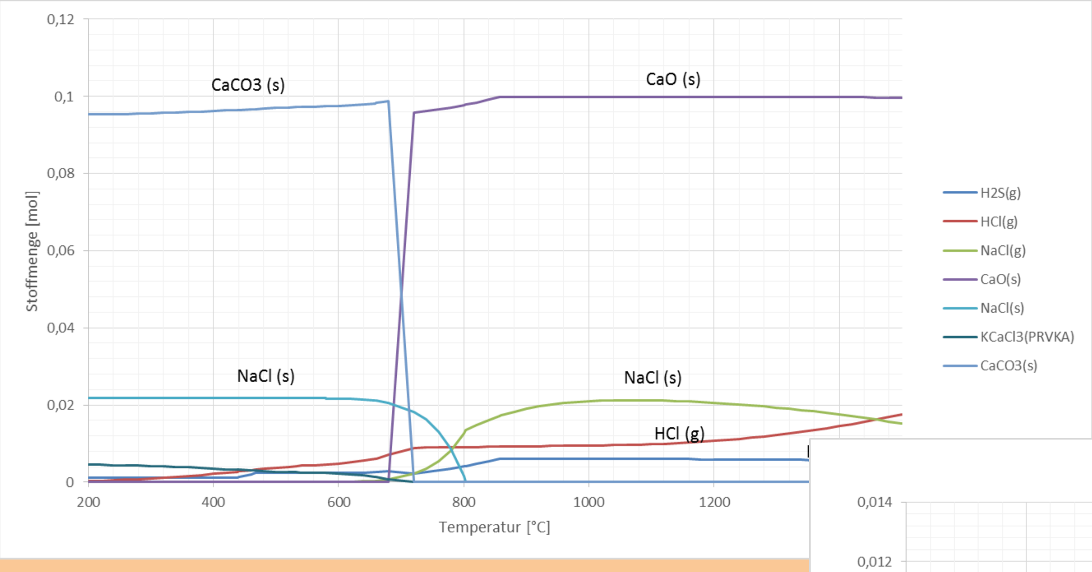
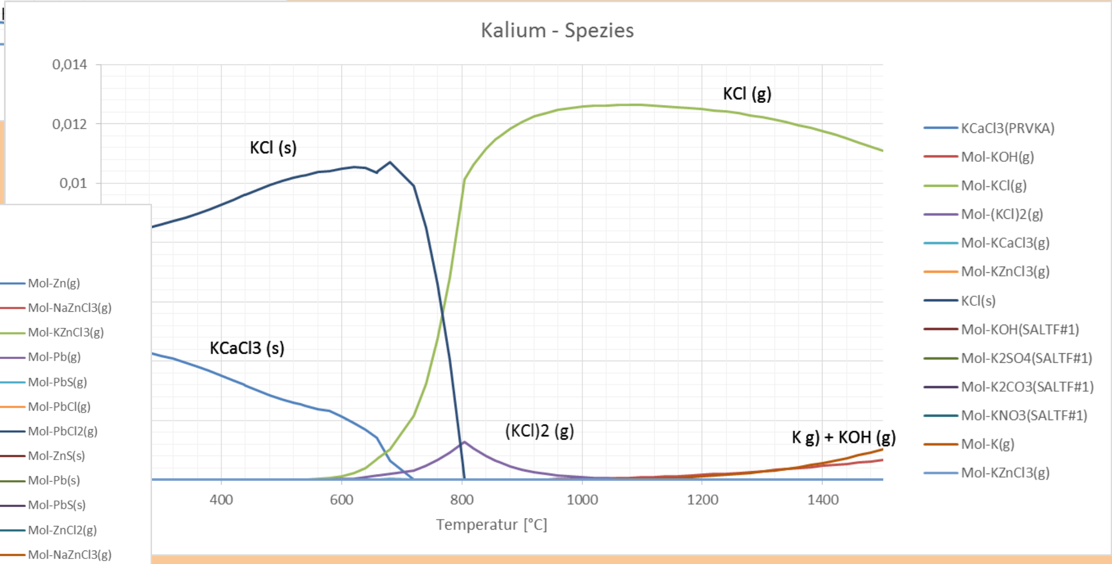
Red.: HCl only, no additional Cl (Case 2)

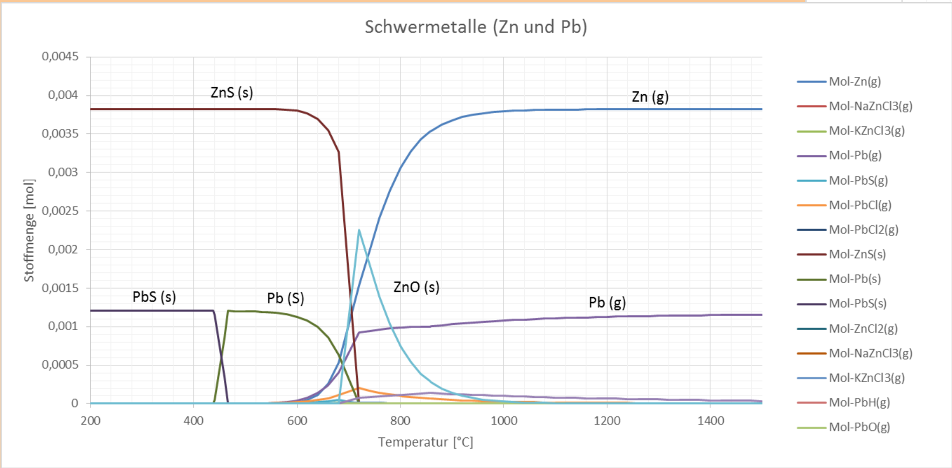


HCl “absorbed“ mainly by Na, K

S “absorbed” mainly by Pb, Zn

CaO; KCl^{g} formation at 700 °C





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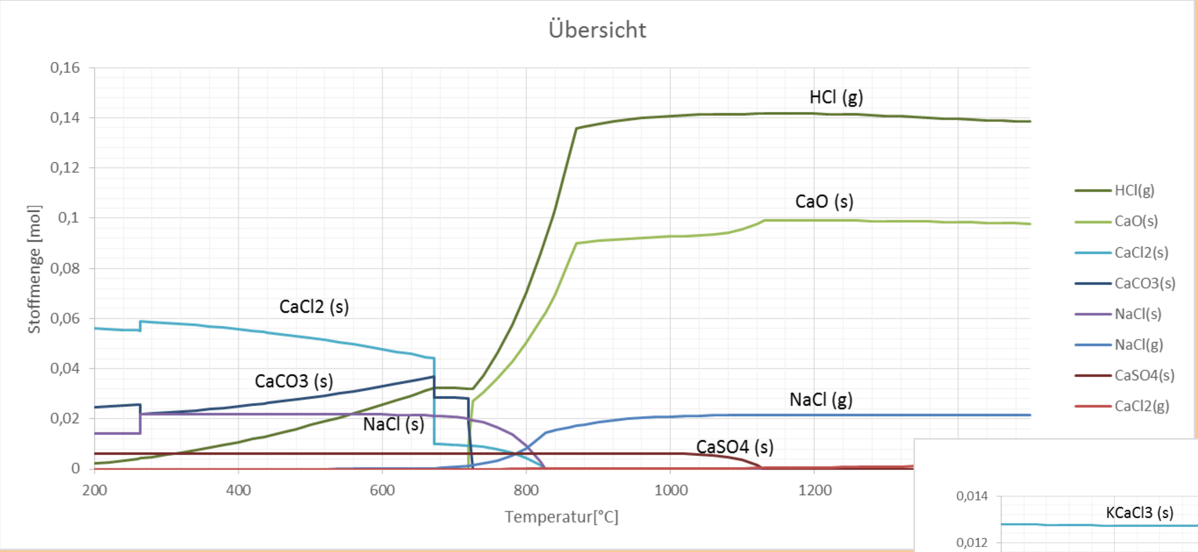
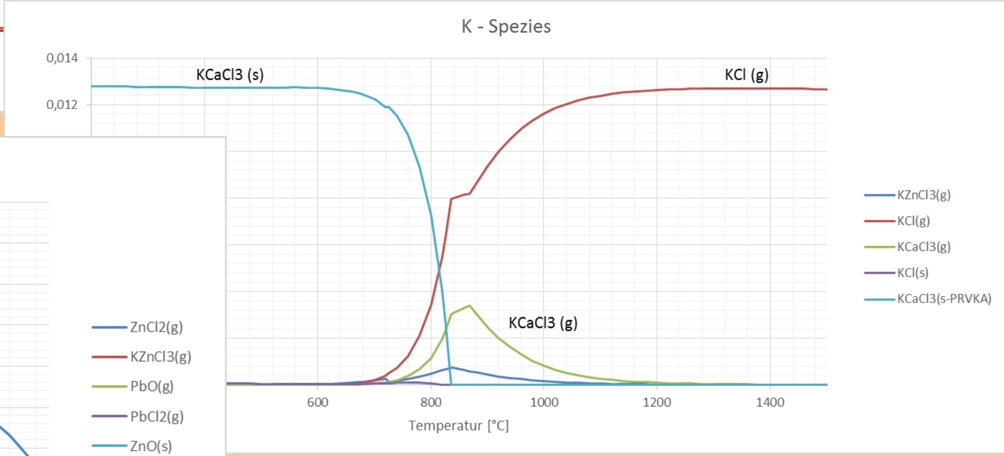
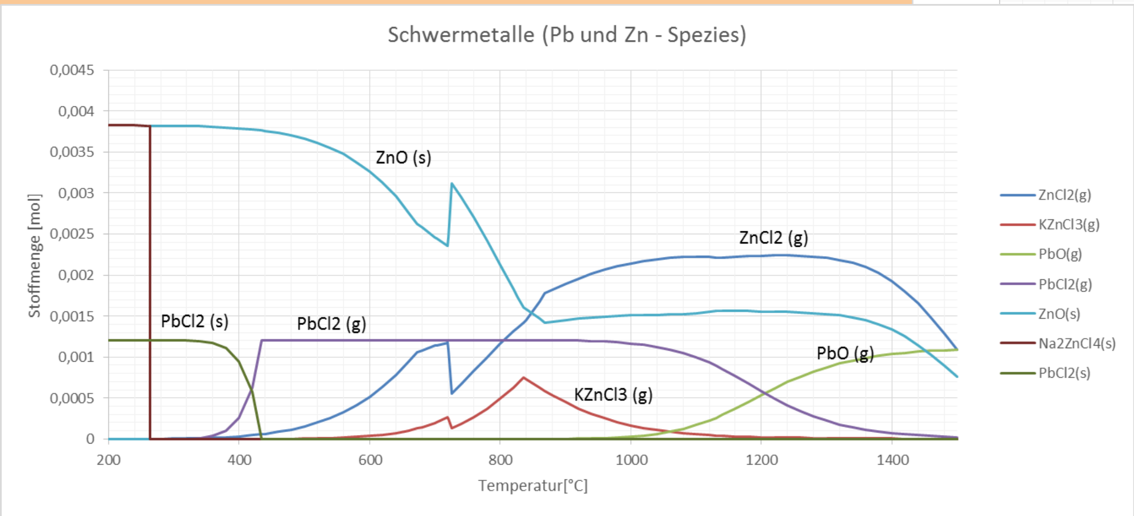
Oxi.: HCl, additional Cl (Case 3) (low S)



Cl to HCl, Na, K, Ca
also to Pb, Zn
S “absorbed” by Ca at first

CaO;KCl^g formation at 800 °C





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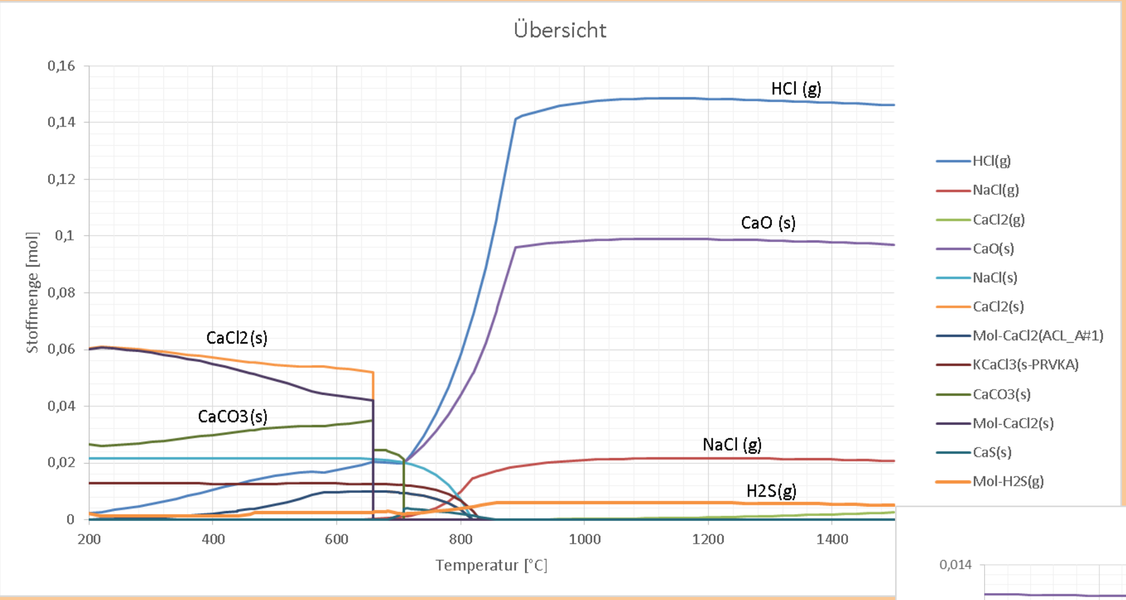
Red.: HCl, additional Cl (Case 4) (low S)



Cl to Na, K;

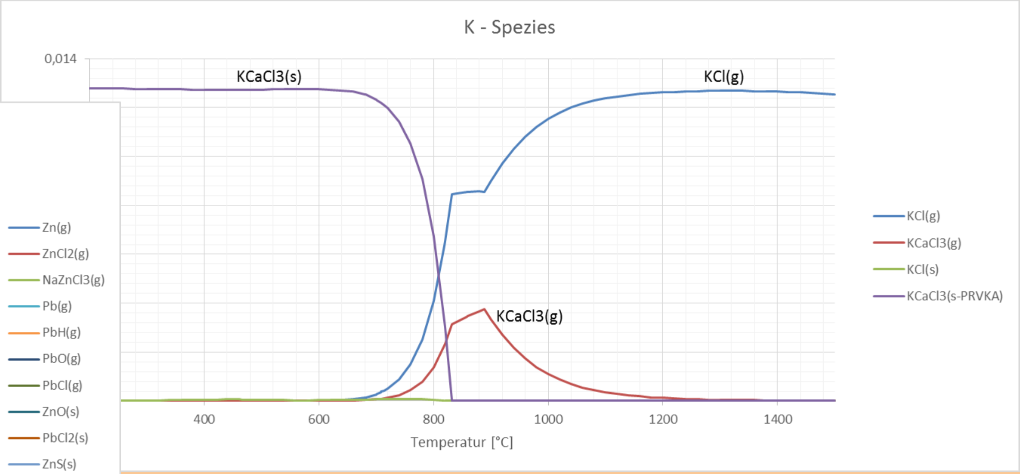
HCl>800°C

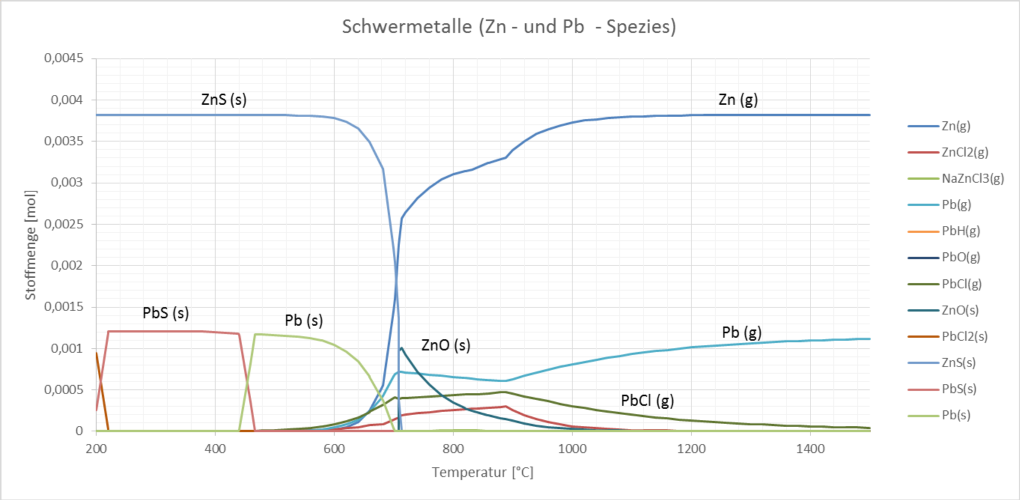
Ca<700°C, less Pb

S to Pb, Zn<700°C

H2S>800°C

CaO,KCl^g formation at 800 °C





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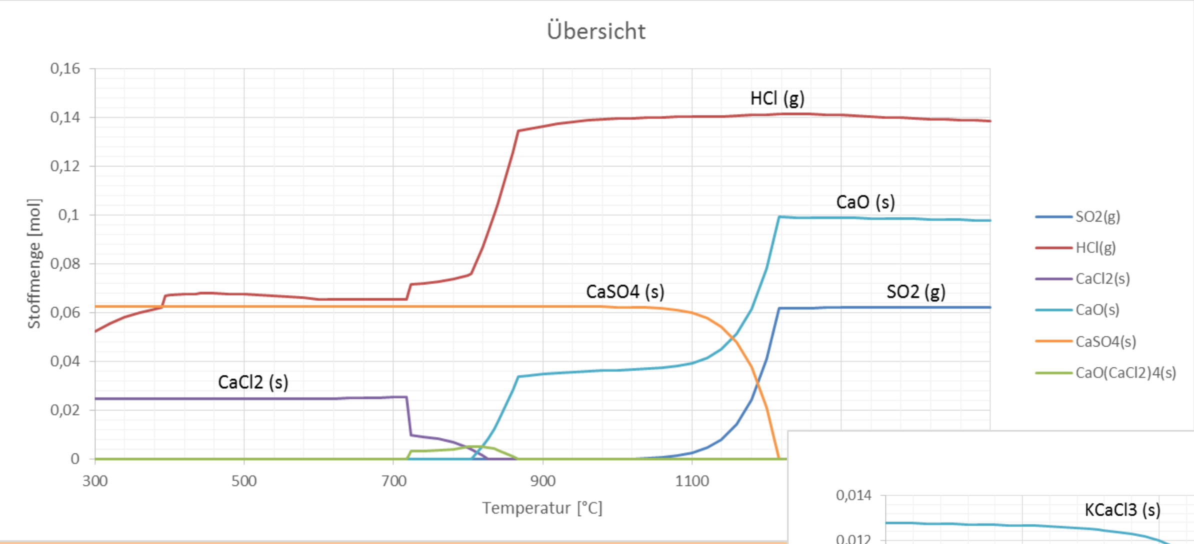
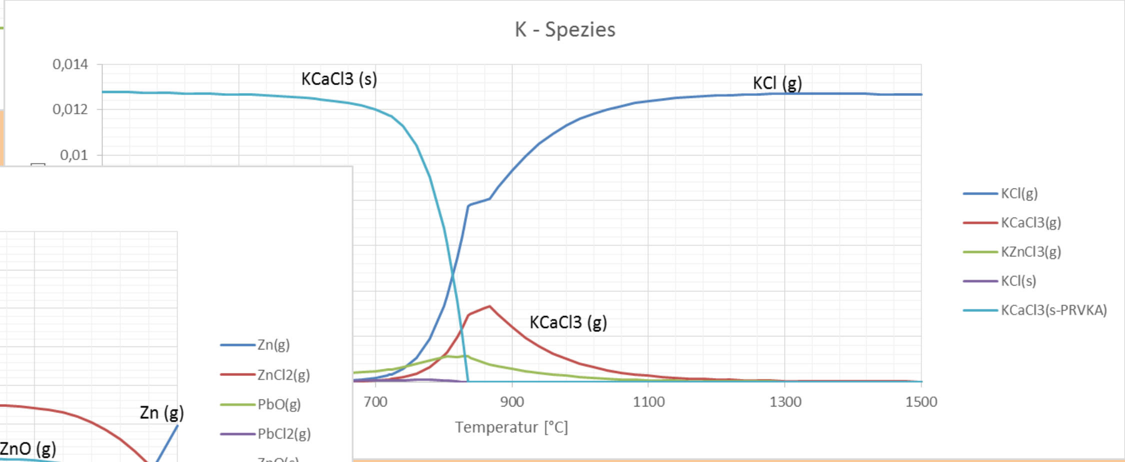
Oxi.: A lot of Cl + S (Case 7)

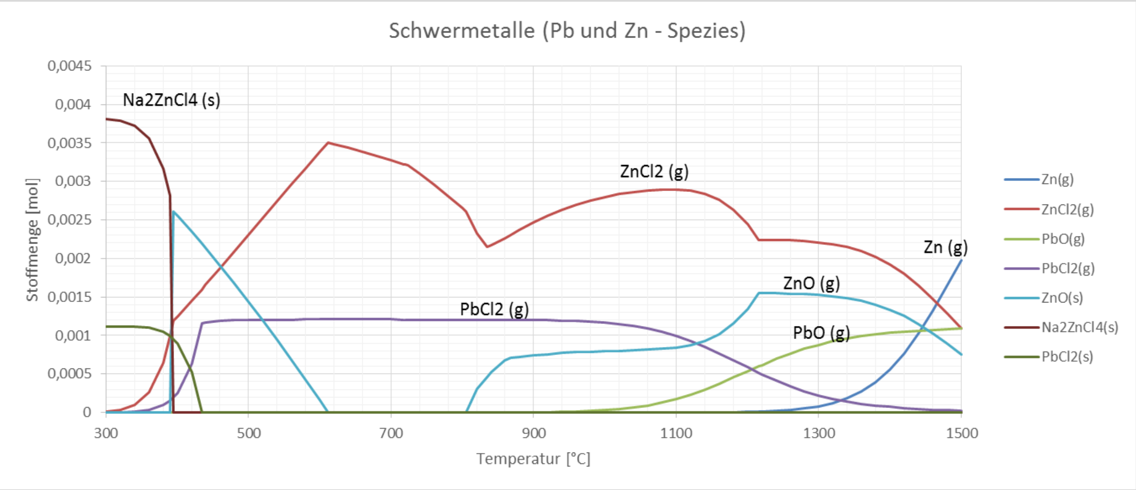


Cl to HCl,Na,K,Pb,Zn and Ca at low T

S to CaSO4<1200°C, SO2>1200°C

CaO,KCl^g^ formation at 800 °C





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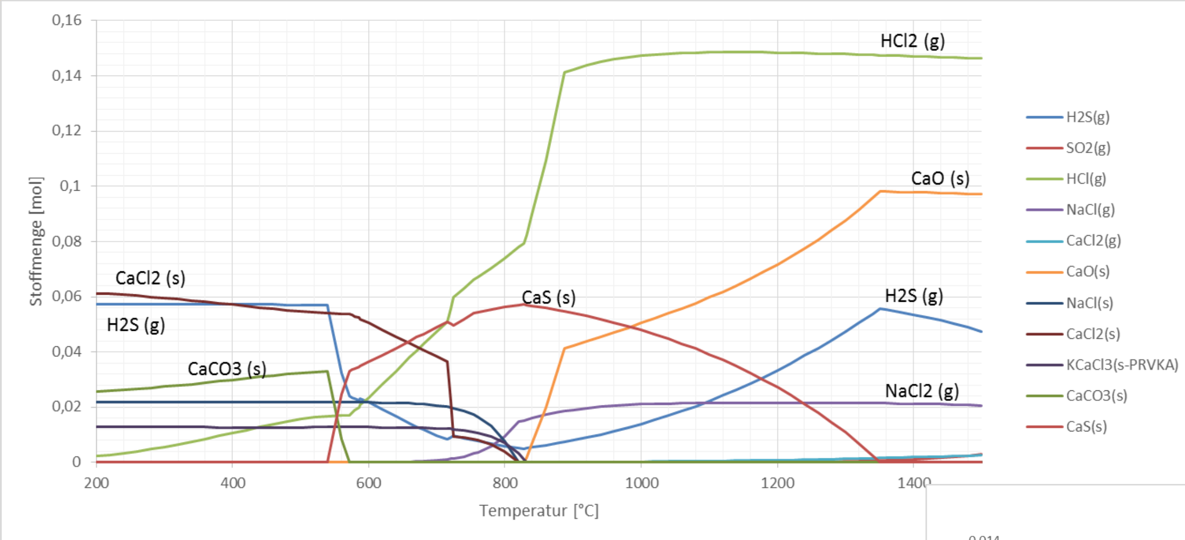
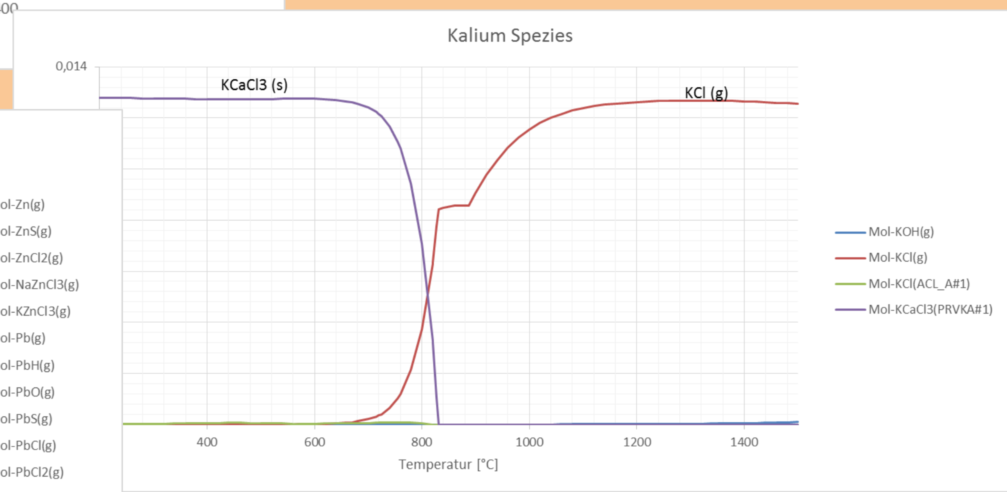
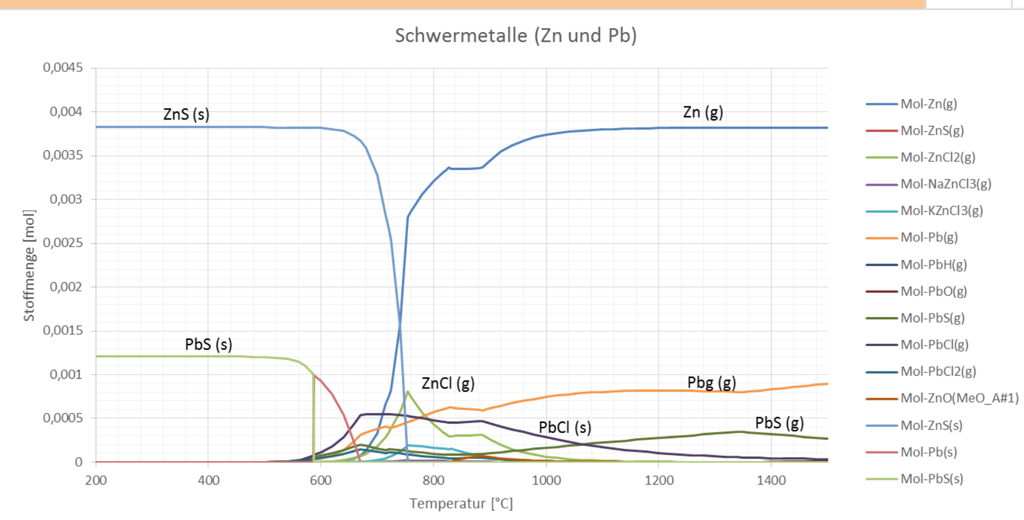
Red.: A lot of Cl + S (Case 8)



Cl to Na,K;
HCl>800°C;
Ca<600°C, less Pb
S to H2S,CaS and
ZnS,PbS at low T

CaO,KCl^g formation >800 °C





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Résumé

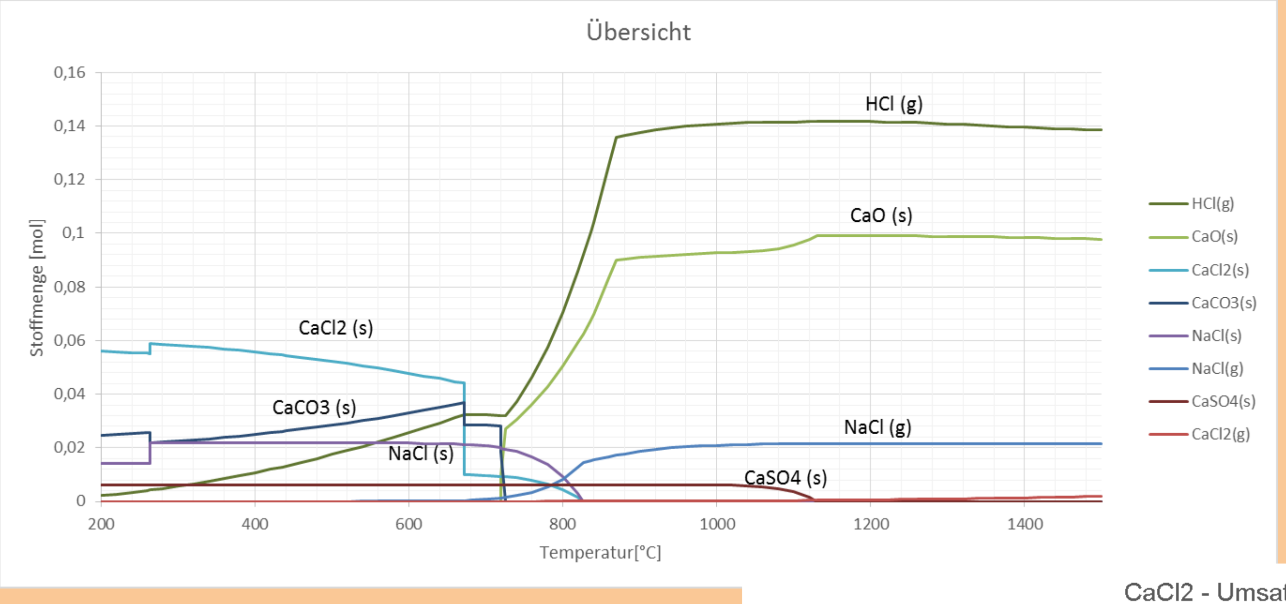
For the waste-to-energy system:

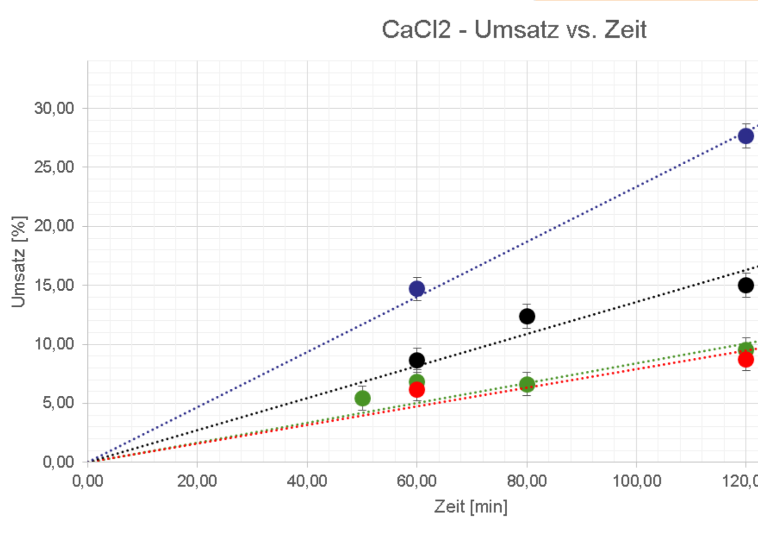
Chlorine: First built species: KCl and NaCl
Next step: T < 800°C to $CaCl_2$
T > 800°C to HCl
Similarity between oxidising and reducing

Sulphur: First built species: PbS and ZnS<700°C
Next step: T<600°C and >1200°C to H_2S
T>600°C and <1200°C to CaS

CaO formation is shifted from 800°C to 1100°C by adding S and/or O

Kinetic Influences





Work of Daniel Ott,
Univ. Augsburg

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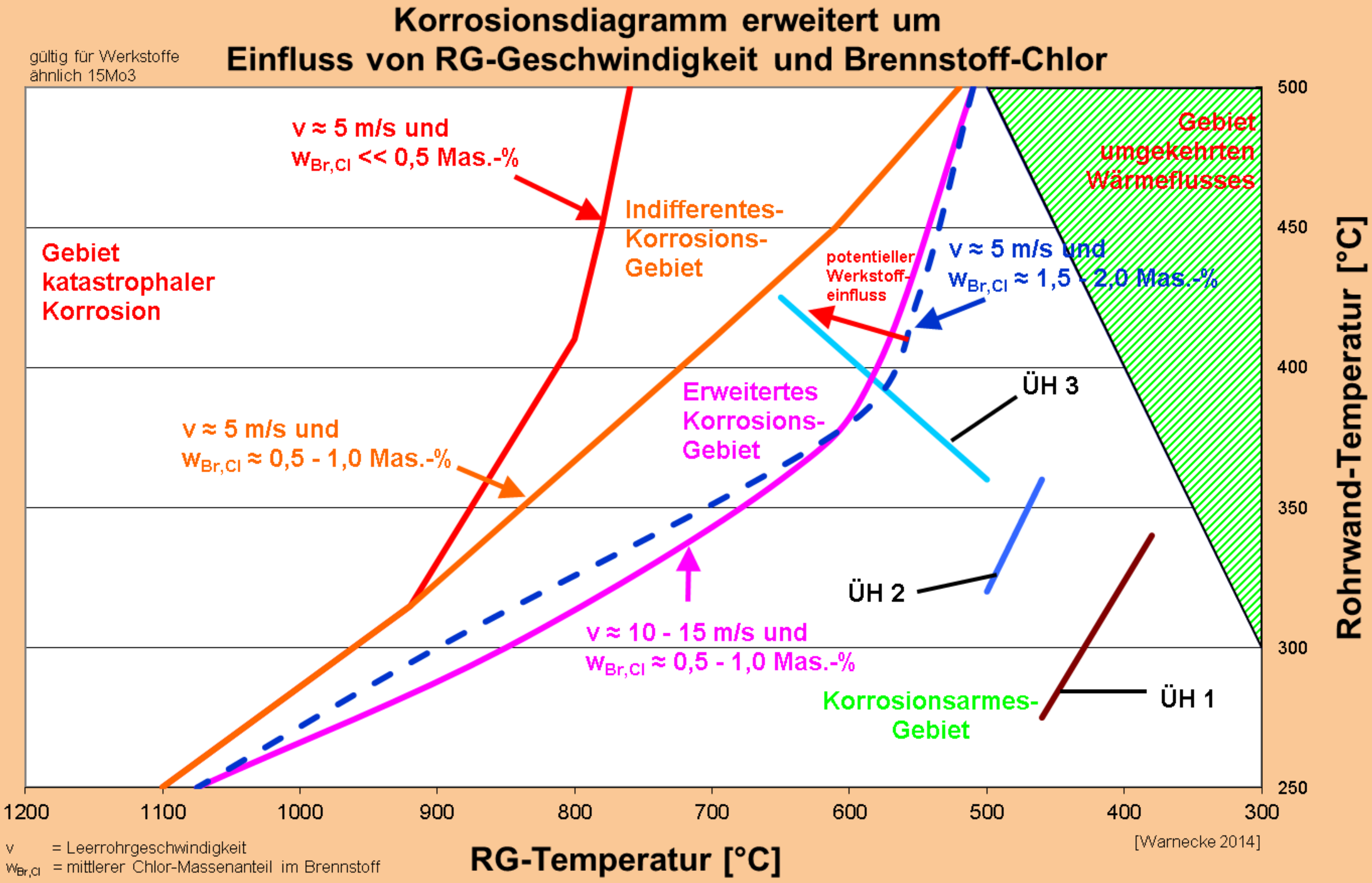
Corrosion Diagram



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4. Summary and Outlook

- Corrosion at superheaters is a severe probleme in waste-to-energy plants. Chlorine content of particle causes this corrosion mainly
- Particle can probably be influenced on their way or react within the deposits
- FactSage delivers a better understanding of the relevant species
- Next step is to extend the species with Si, Al, Fe and investigate the particle consistence
- Kinetic investigations will be added to the thermodynamic calculations

Thank you for your attention and …

many thanks to BMBF for funding MatRessource and within this our project

"VOKos"

as well as to PtJ for managing the whole MatRessource measure!

GEFÖRDERT VOM
Bundesministerium für Bildung und Forschung

MatRessource
Die Förderinitiative des BMBF zu Materialien für Ressourceneffizienz

ptJ
Projektträger Jülich
Forschungszentrum Jülich