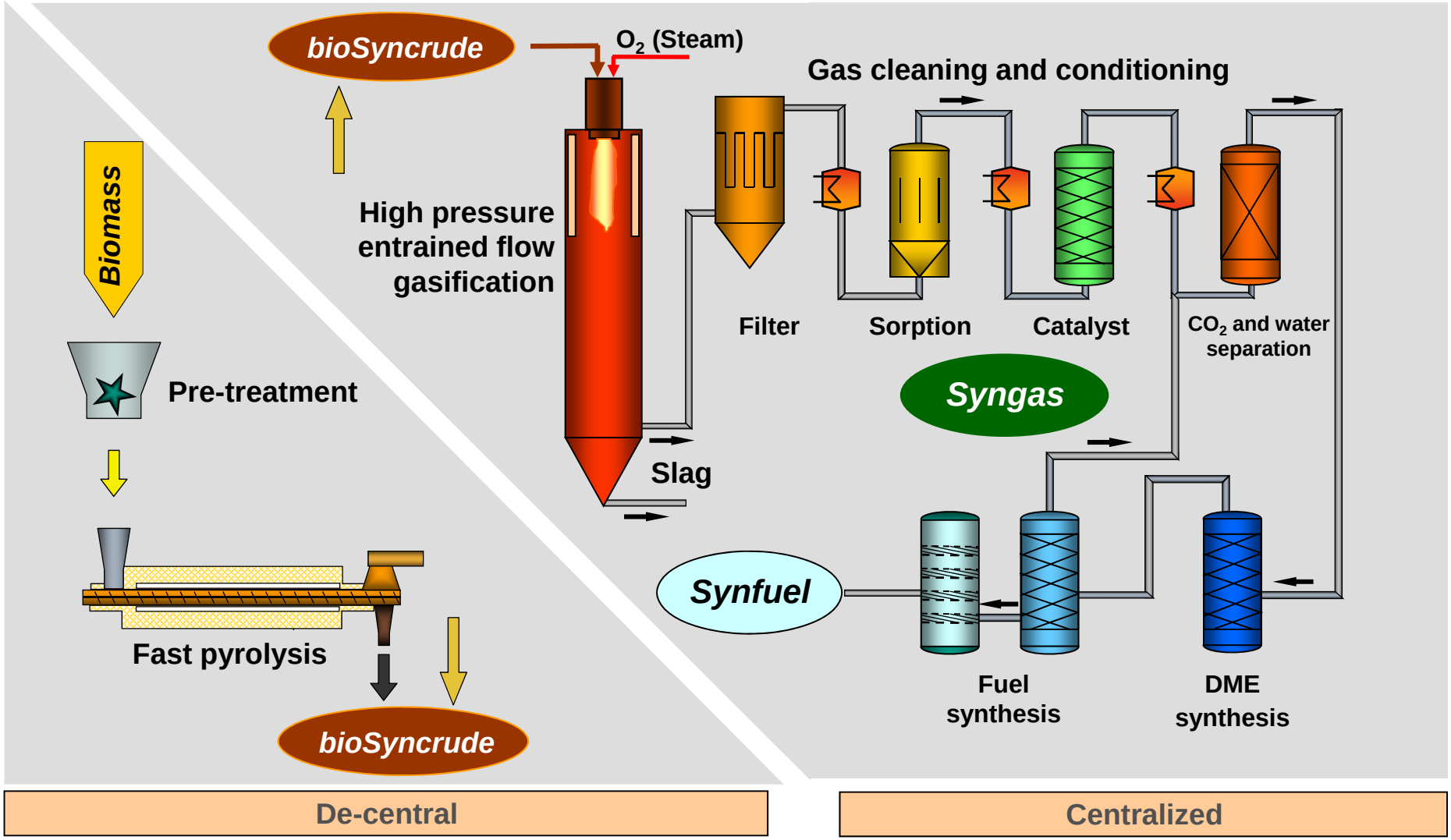
Karlsruher Institut für Technologie

Gas Sampling, Measurement and Analysis on the bioliq ® -EFG

26.10.2016 Mark Eberhard

Institut für Technische Chemie, Vergasungstechnologie, ITC vgt

Technology scheme



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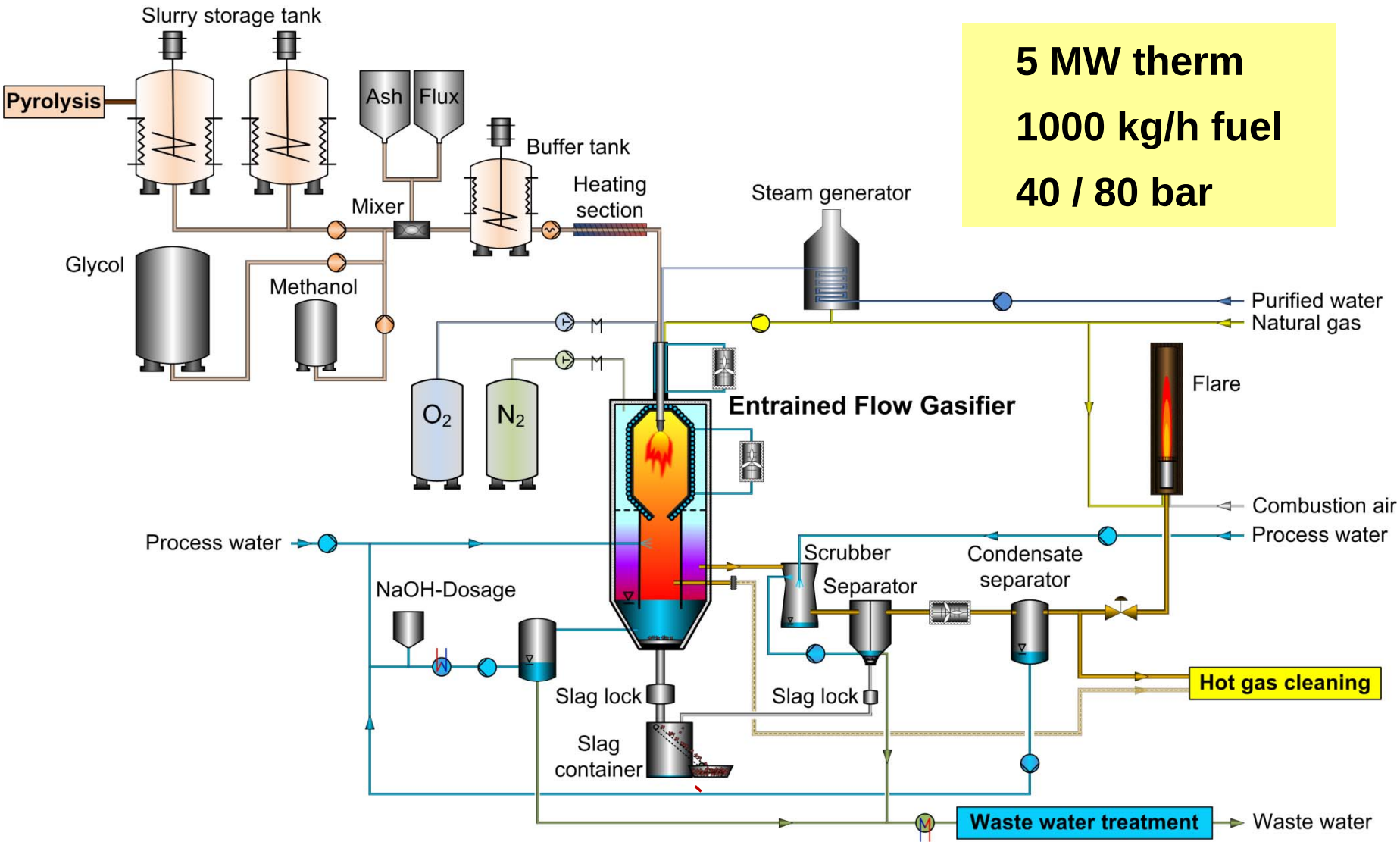
bioliq® - High Pressure Entrained Flow Gasifier



5 MW therm

1000 kg/h fuel

40 / 80 bar

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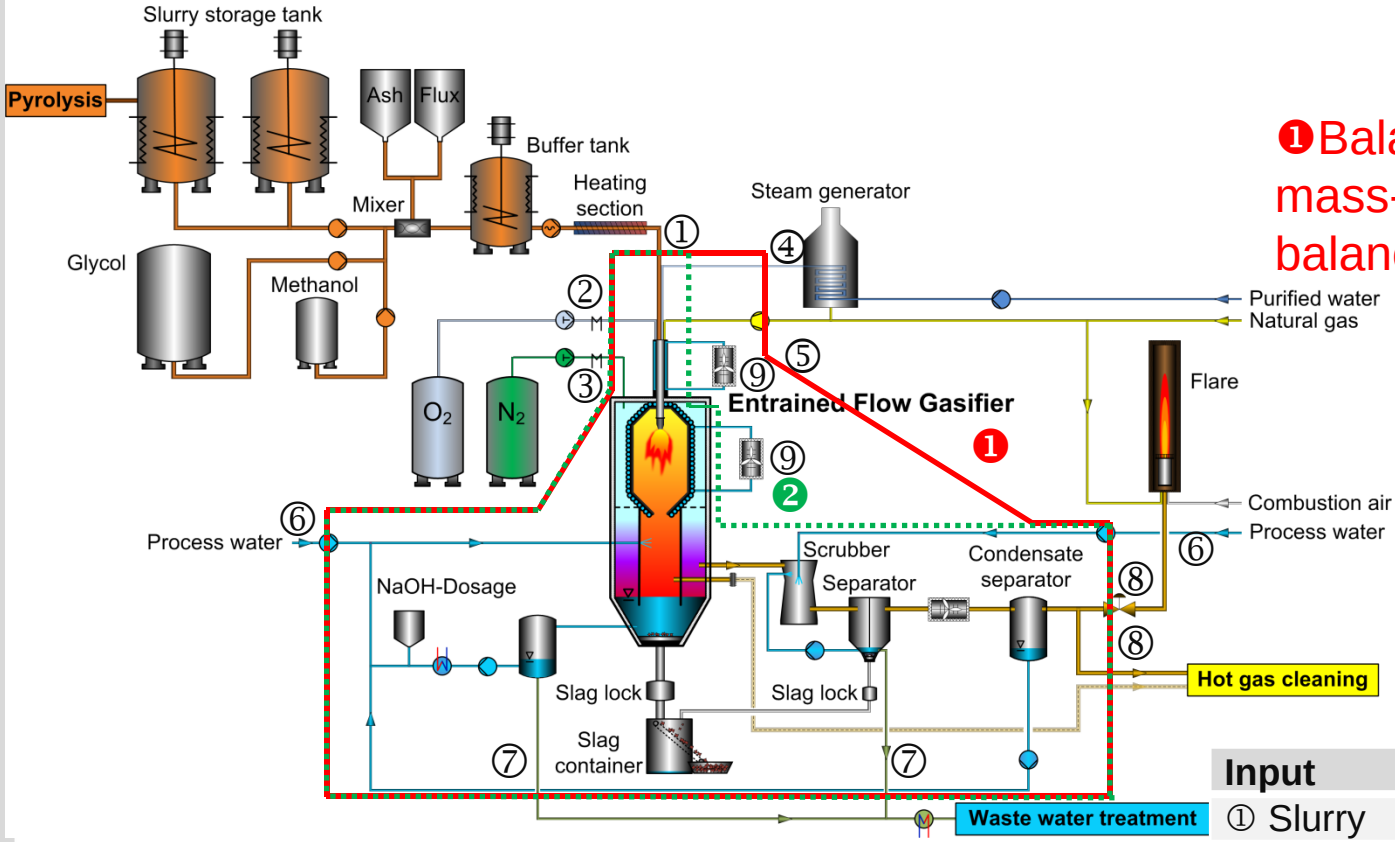
Balance mass, species and energy



❶Balancing borders for mass- and species - balance

❷ Balancing borders for energy balance

Input	Output
① Slurry	⑦ Waste water
② Oxygen	⑧ Syngas
③ Nitrogen	
④ Steam	
⑤ Natural gas	
⑥ Process water	
⑨ Cooling water	⑨ Cooling water

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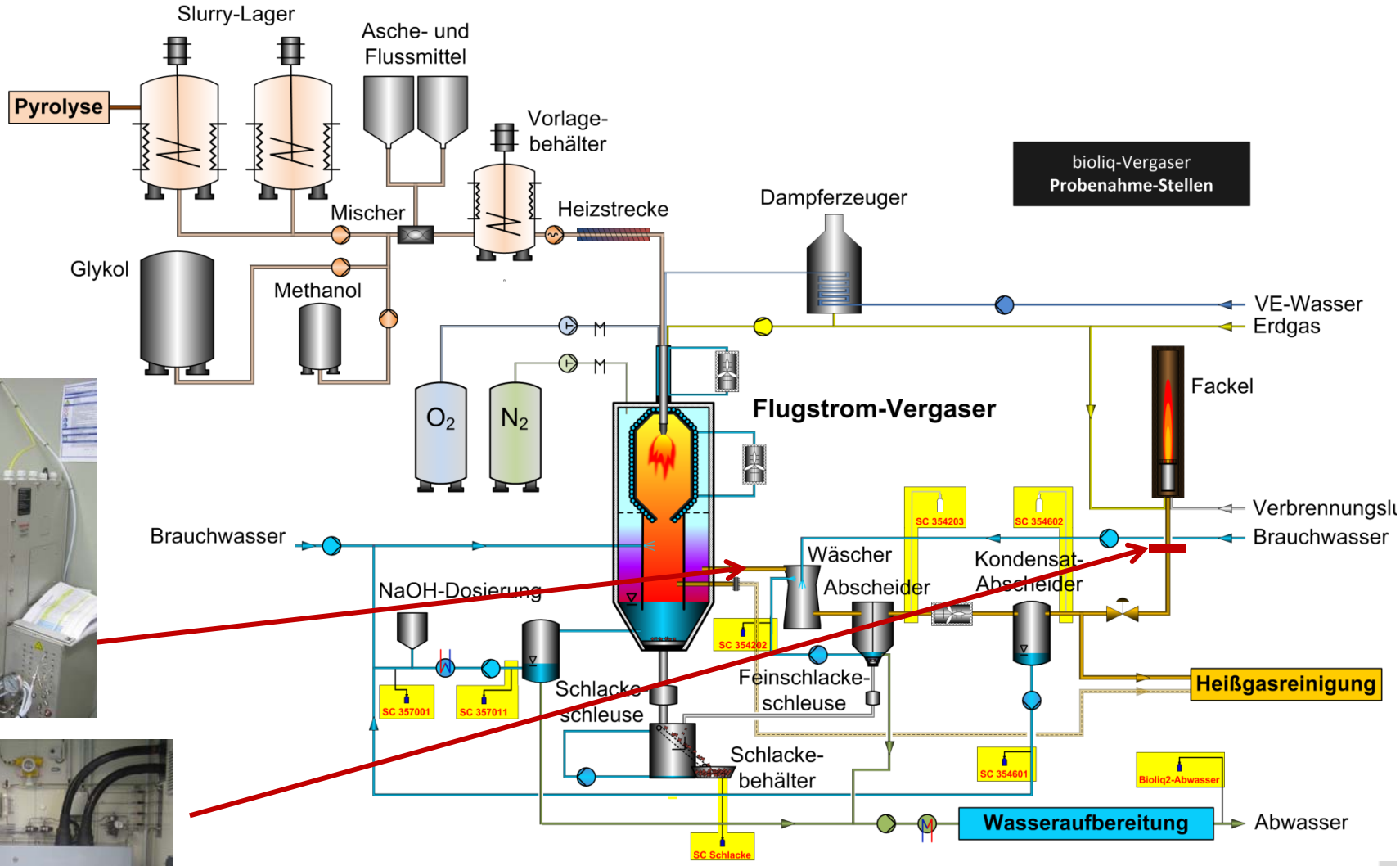
Points for Sampling



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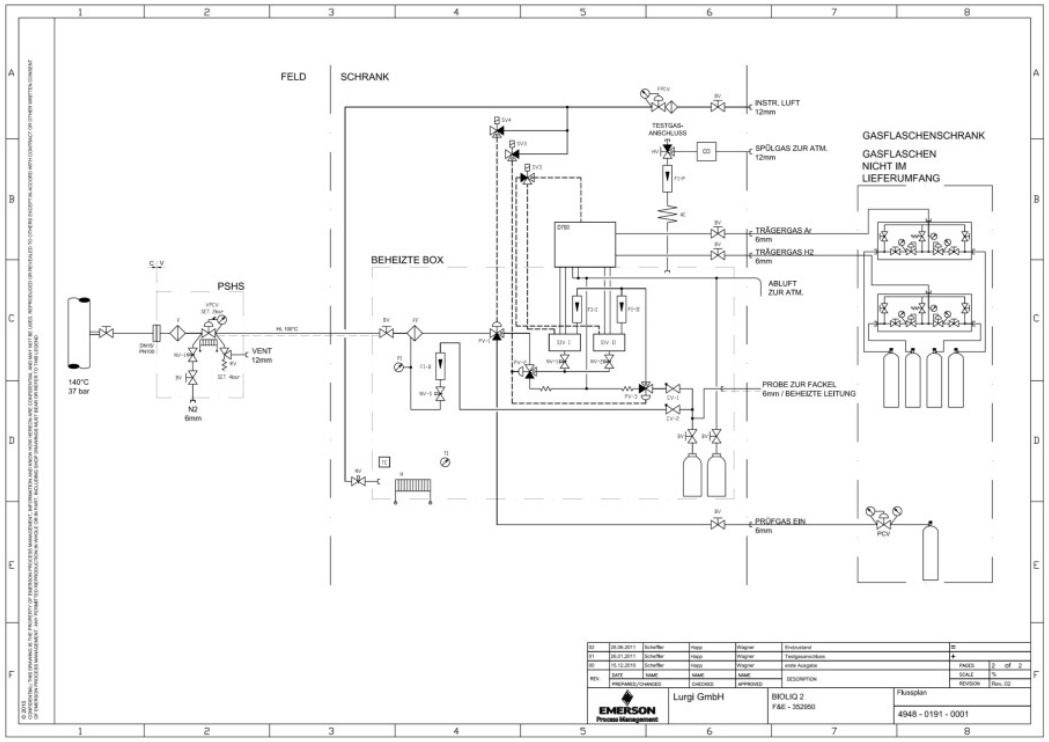
Process gas chromatography

H_2	CO	CO_2	N_2	CH_4
28-33	28-37	18-27	12-18	<0,1-0,3



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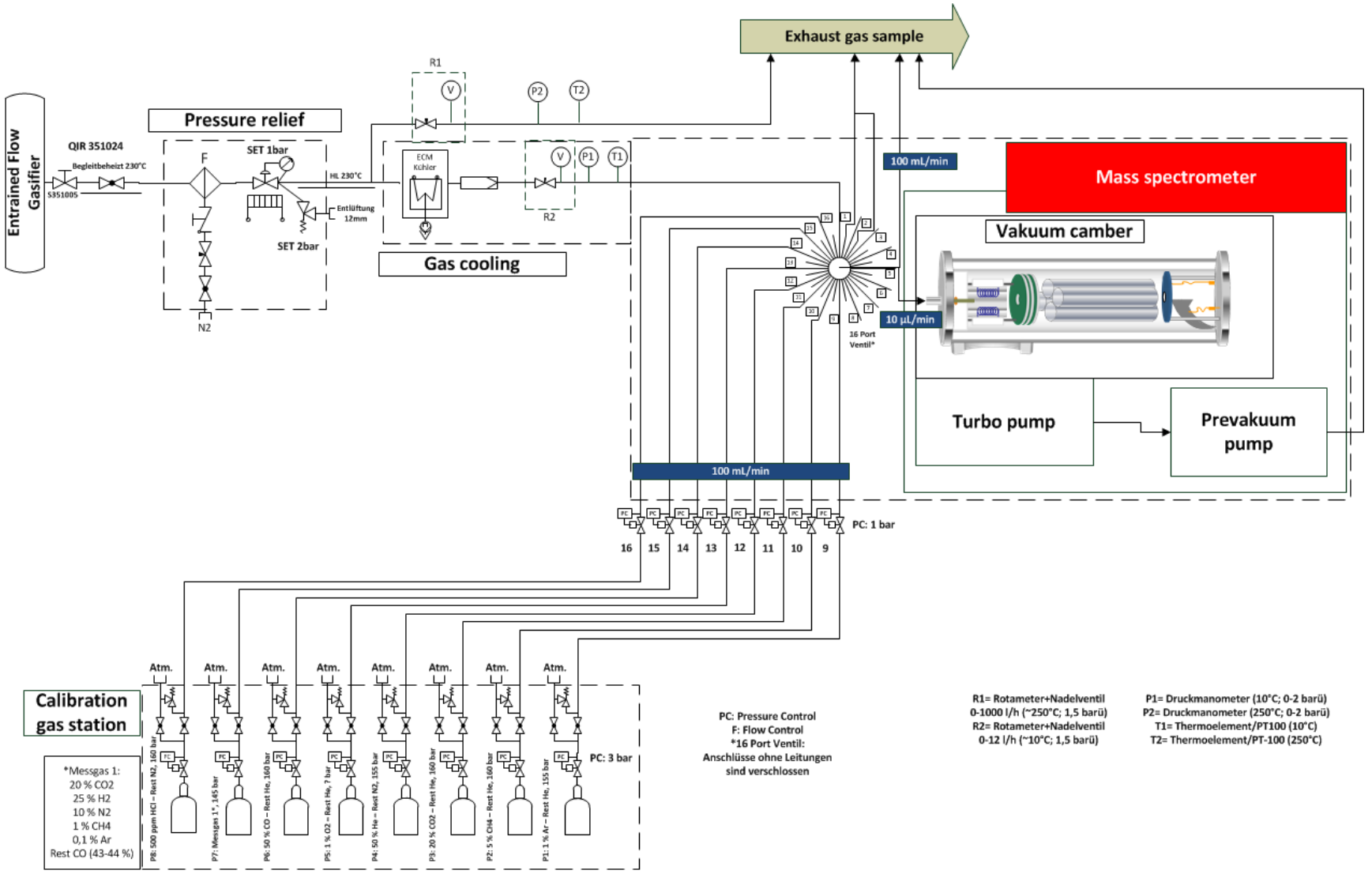
Mass spectrometer



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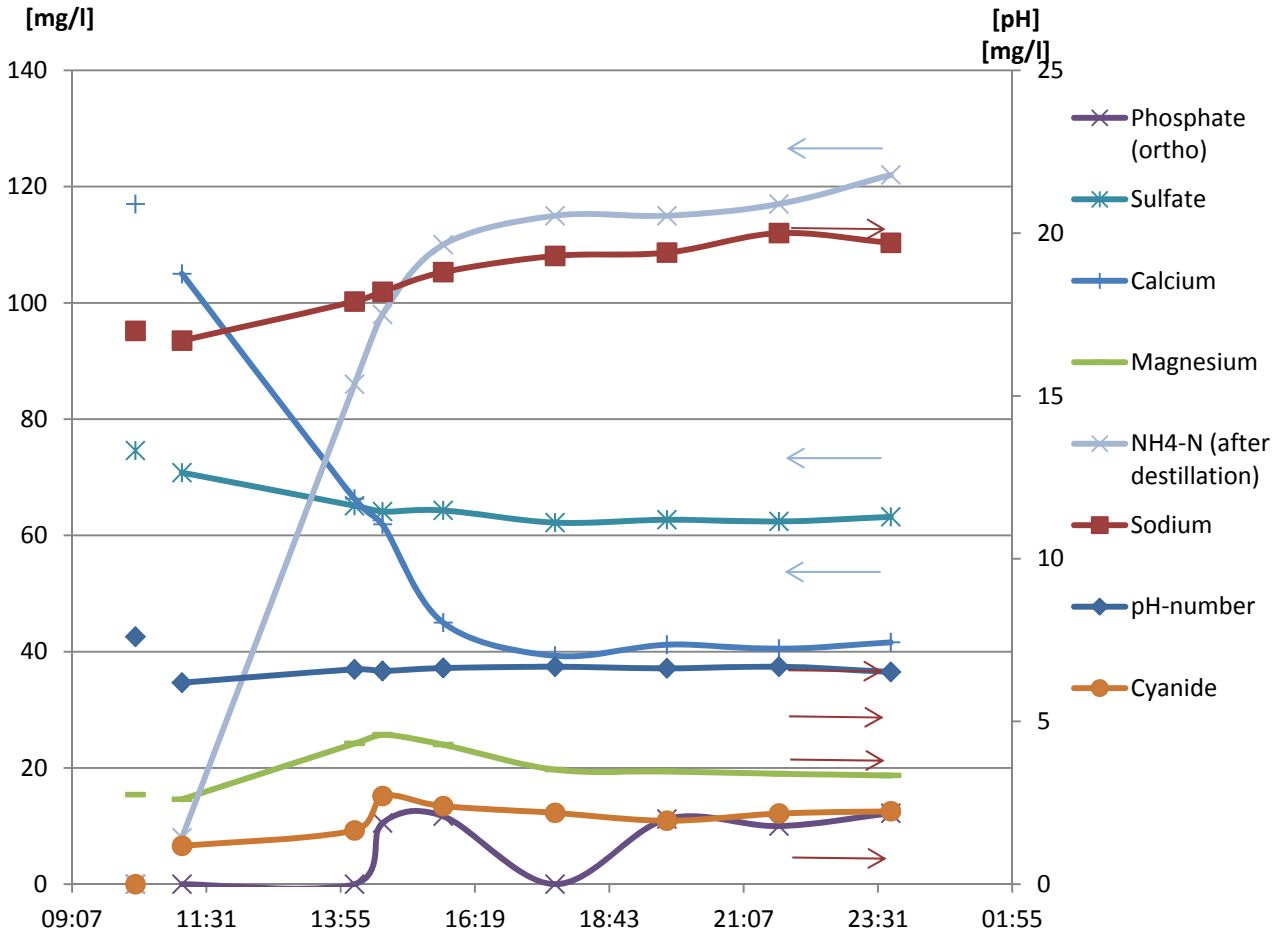
Process water

Parameter	Unit
pH-number	
Chloride	mg/l
Nitrate	mg/l
Phosphate	mg/l
Sulfate	mg/l
Cyanide	mg/l
Calcium	mg/l
Potassium	mg/l
Magnesium	mg/l
Sodium	mg/l
Phosphorus	mg/l
Sulfur	mg/l
NH_4-N	mg/l
Total dry residue	mg/l
Total dry residue	%
Ash 550°C	mg/l
Ash 550°C	%
Ash 815°C	mg/l
Ash 815°C	%
Filtrate	l
Residue (105°C)	mg



Liquid Chromatography
ICP-IOS „inductively coupled plasma optical emission spectrometry“

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Slag analysis

Carbon	%wt	0,225
Chlorine	%wt	0,014
Sodium oxide	%wt	0,178
Magnesium oxide	%wt	3,07
Silicium oxide	%wt	57,9
Aluminium oxide	%wt	1,4
Phosphorus oxide	%wt	2,83
Potassium oxide	%wt	21,5
Calcium oxide	%wt	9,94
Manganese oxide	%wt	0,166
Iron oxide	%wt	1,04
Nickel oxide	%wt	0,01

Melting behavior:		
Sintering temperature	°C	703
Refractory deformation temperature	°C	855
Spherical temperature	°C	931
Hemispherical temperature	°C	1134
Flow temperature	°C	1244

Method: XRF spectroscopy, hot stage microscop

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Balance Main Components

			V11 (40bar)		V26 (40bar)	
Balances						
M balance	Input	$\dot{m}$ [kg/h]	3959,2		4156	
	Output	$\dot{m}$ [kg/h]	3846,3		3999	
	Difference	$\dot{m}$ [kg/h]	-102,9	97,2%	-156,9	96,2%
C balance	Input	$\dot{m}$ [kg/h]	411,6		421	
	Output	$\dot{m}$ [kg/h]	410,9		433	
	Difference	$\dot{m}$ [kg/h]	-0,7	99,8%	12	102,9%
H balance	Input	$\dot{m}$ [kg/h]	297		325	
	Output	$\dot{m}$ [kg/h]	287,7		313	
	Difference	$\dot{m}$ [kg/h]	-10	96,7%	-12	96,3%
O balance	Input	$\dot{m}$ [kg/h]	2853		3169	
	Output	$\dot{m}$ [kg/h]	2723		3042	
	Difference	$\dot{m}$ [kg/h]	-130	95,4%	-127	96%
N balance	Input	$\dot{m}$ [kg/h]	353		208	
	Output	$\dot{m}$ [kg/h]	372,3		211	
	Difference	$\dot{m}$ [kg/h]	20	105,6%	3	101,1%
Q balance	Input	kW	15595		15031	
	Output	kW	14893		14891	
	Difference	kW	-702	95,5%	-140	99,1%

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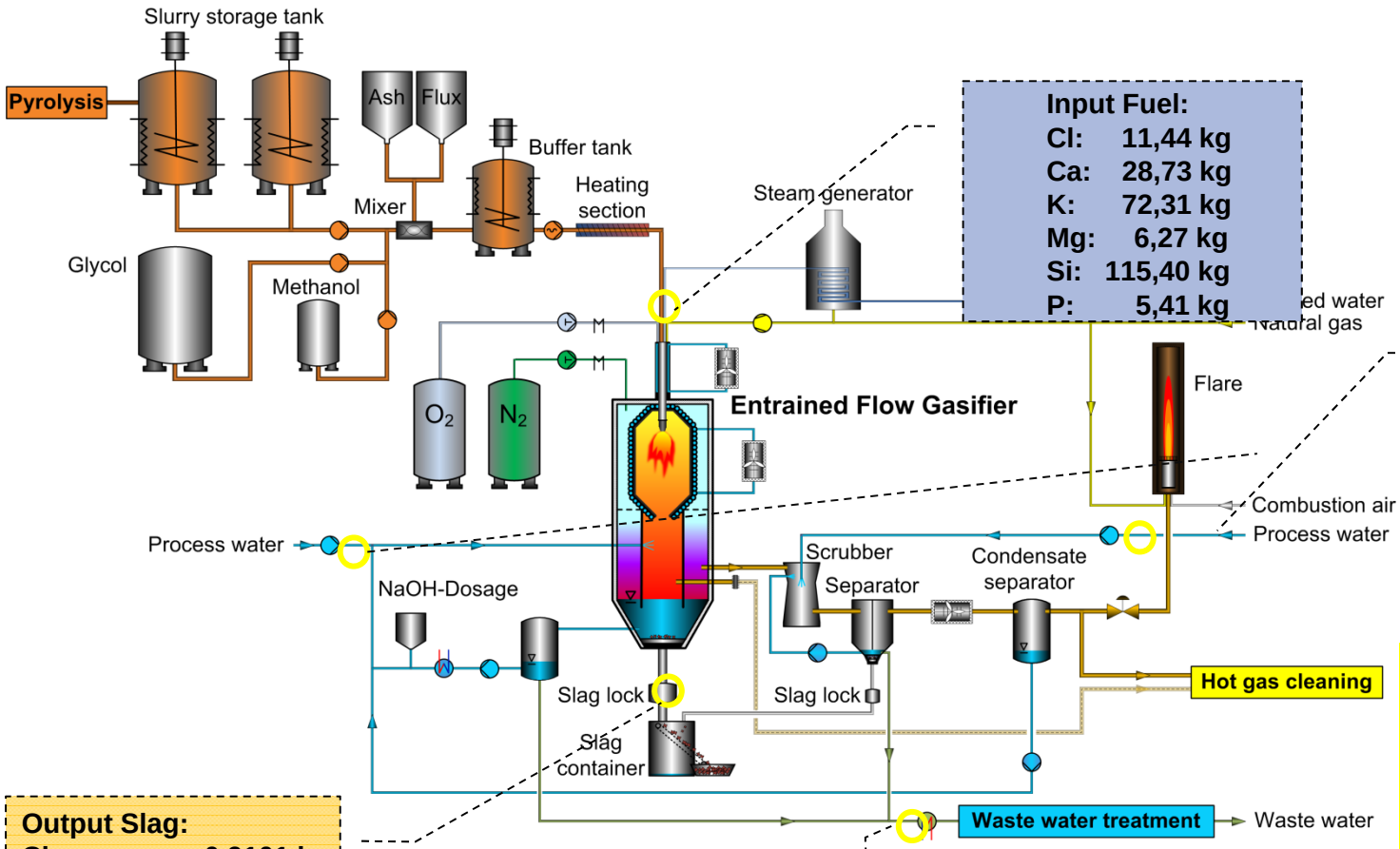
Balance Anorganics



Input Fuel:

Cl:	11,44 kg
Ca:	28,73 kg
K:	72,31 kg
Mg:	6,27 kg
Si:	115,40 kg
P:	5,41 kg

Input Water

Cl:	0,65 kg
Ca:	2,11 kg
K:	0,07 kg
Mg:	0,27 kg
Si:	0,097 kg
P:	0,002 kg

Output Slag:

Cl:	0,9101 kg
Ca:	25,78 kg
K:	54,14 kg
Mg:	5,925 kg
Si:	108,73 kg
P:	4,583 kg

Output Water:

Cl:	9,91 kg
Ca:	2,53 kg
K:	22,63 kg
Mg:	1,012 kg
Si:	5,568 kg
P:	0,0164 kg

Balance:

Slag/ash:	78,31%
Cl:	90,03%
Ca:	91,82%
K:	106,06%
Mg:	106,01
Si:	98,96
P:	89,41%

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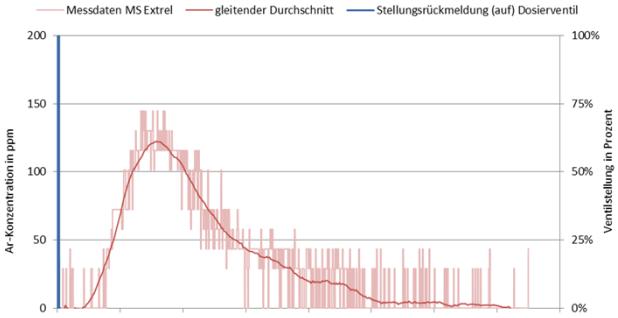
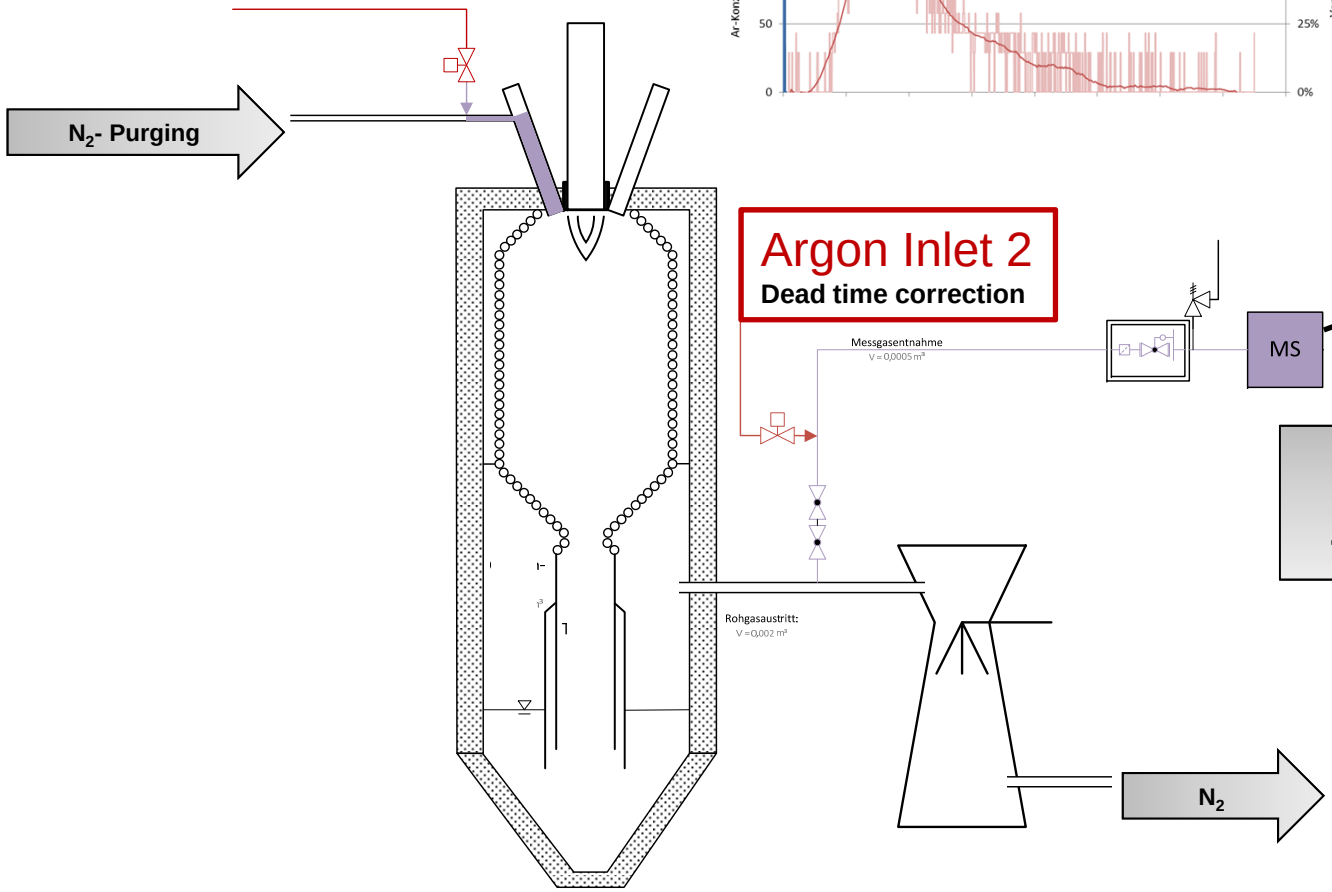
Online Residence Time Measurement





Mass spectrometer

- time resolution 2 seconds

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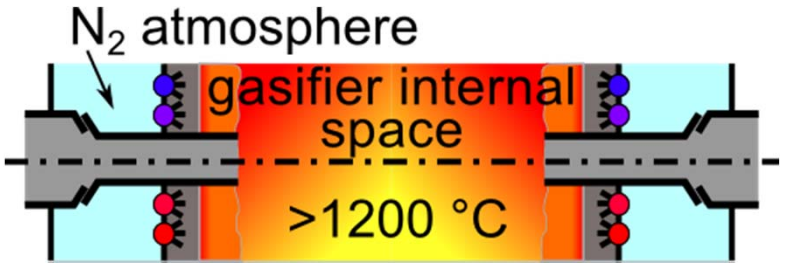
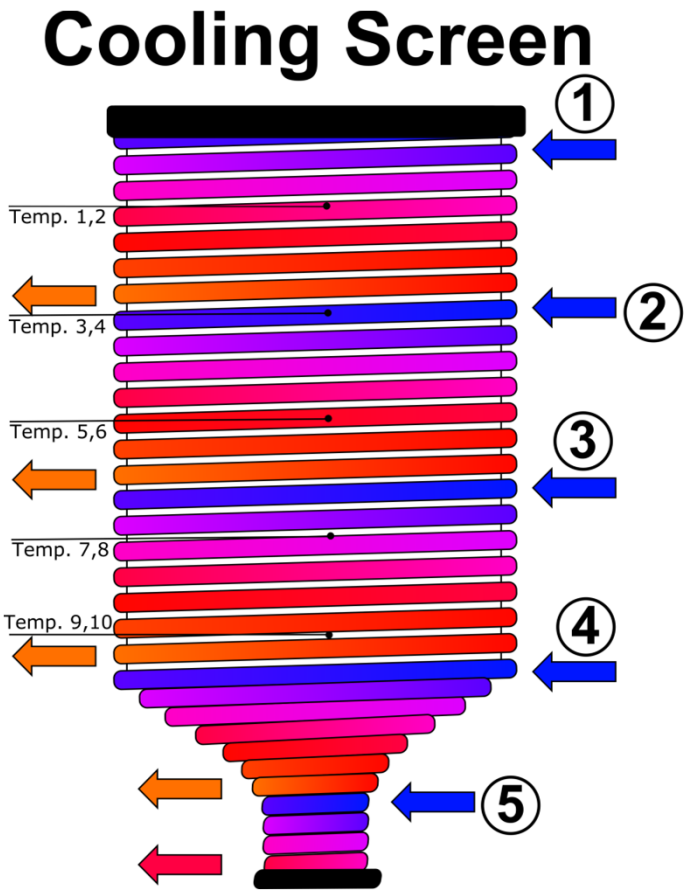
Cooling screen features

	Temperature °C	
	V 11	**V 26**
Temp. 1,2	**711**	**768**
Temp. 3,4	**690**	**728**
Temp. 5,6	**724**	**760**
Temp. 7,8	**761**	**801**
Temp. 9,10	**677**	**794**





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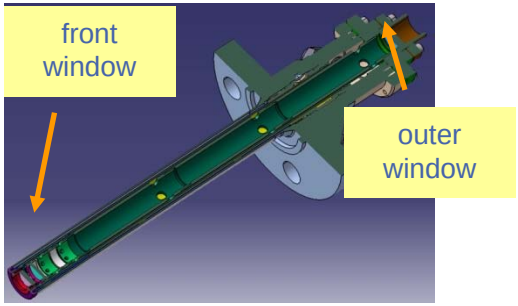
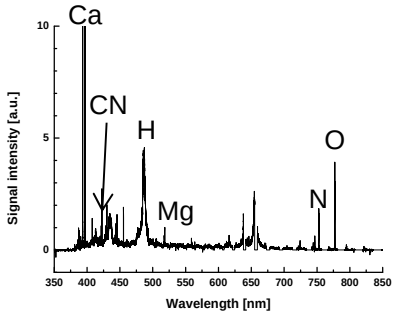
Development of diagnostic methods for gasifiers

- **Emission spectroscopy**
  - Broad range of stable and meta stable combustion products and elements detectable.
- **Laser induced incandescence (LII)**
  - Measurement of soot volume fraction and particle size.
- **Laser induced breakdown spectroscopy (LIBS)**
  - Measurement of the elemental composition in the gas phase.
- **Absorption spectroscopy**
  - Measurement of species concentration (e.g. H_2O, CO, CO_2 CH_4, NO, NO_2, HCN, O_2, HCl, NH_3).





LIBS spectrum from gas phase measurement in REGA gasifier

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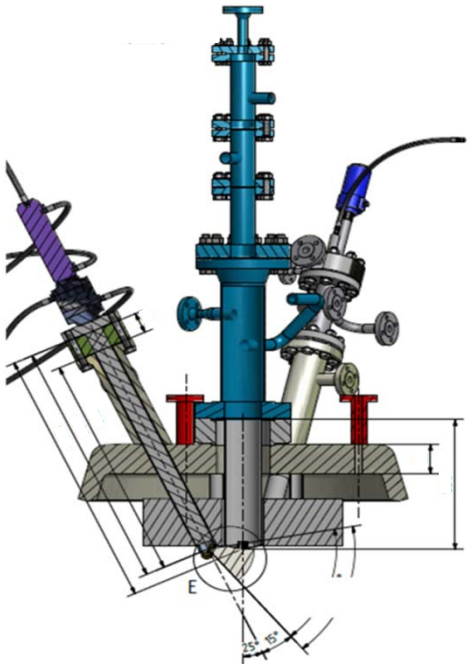
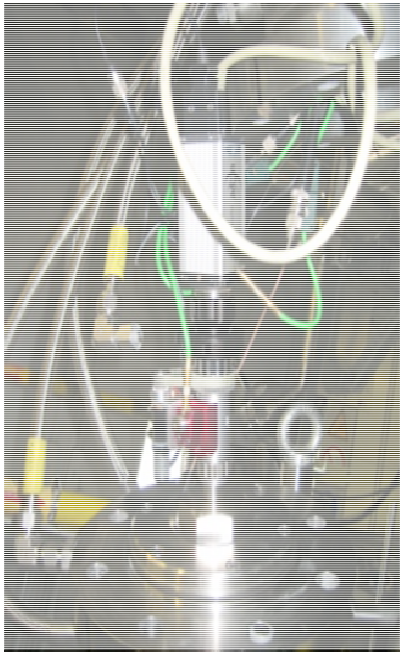
bioliq® - High Pressure Optical Borescope

camera based systems for analysis of atomization

- High Dynamic Range Camera
- High Speed Camera





gasifier flame at 40 bar

cooperation: KIT Institute for Applied Computer Science, IAI

bioliq® Pilot plant

Gefördert durch:

Bundesministerium für Ernährung und Landwirtschaft

aufgrund eines Beschlusses des Deutschen Bundestages

FNR Fachagentur Nachwachsende Rohstoffe e.V.

bioliq Biomass to Liquid Karlsruhe

KIT Karlsruher Institut für Technologie

Partners:

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MAT Mischanlagentechnik GmbH

MUT ADVANCED HEATING

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