

REINHOLD ENVIRONMENTAL®



2026 Reinhold/PCUG Round Table Presentation

Hosted by TVA, Southern Company and Vistra
in the Sonesta Nashville Airport Hotel, Nashville, TN
on June 22-23, 2026

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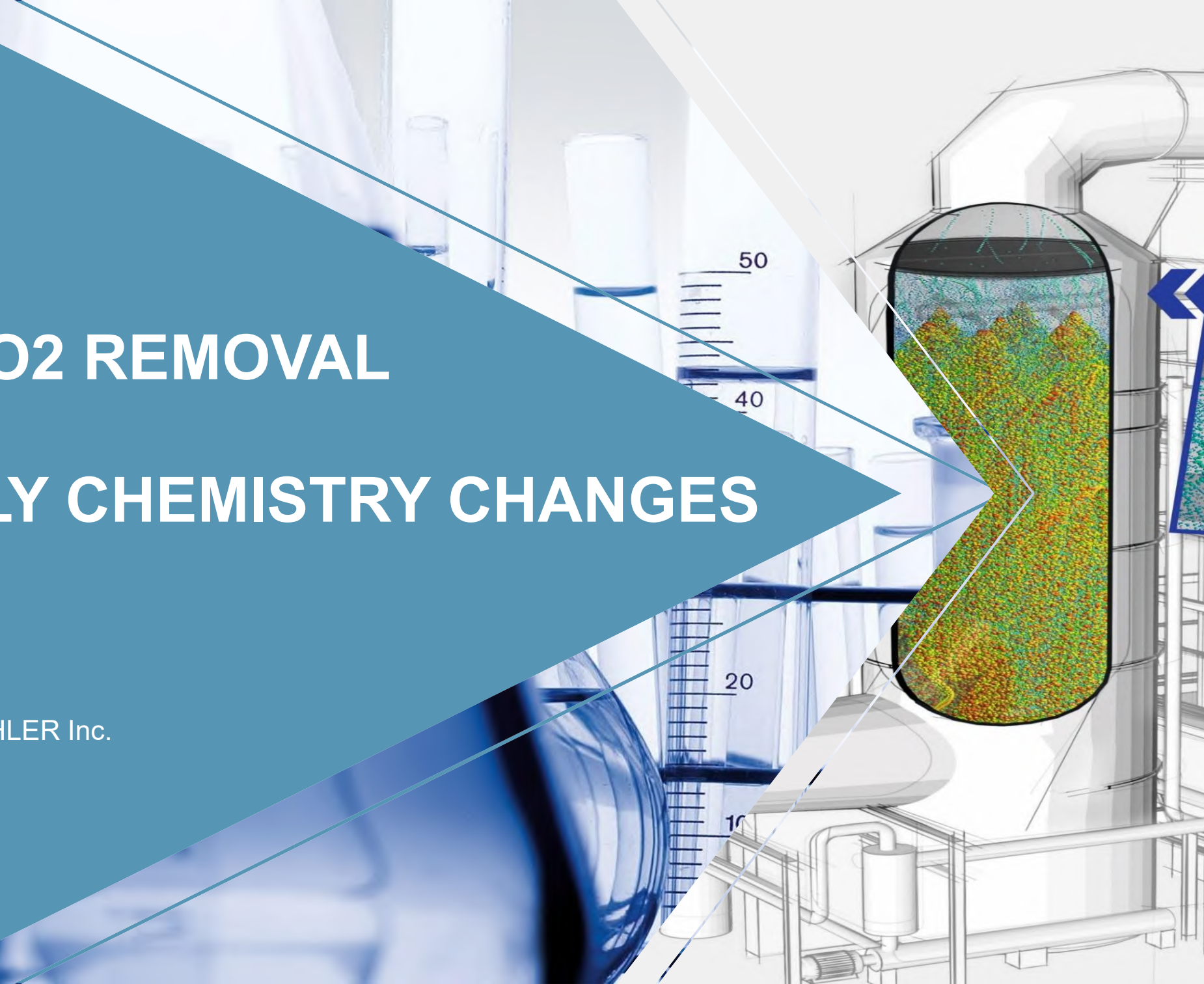
2026 REINHOLD/PCUG CONFERENCE

NASHVILLE JUN 20, 2026 – JUN 25, 2026

THOMAS SCHRÖDER LECHLER Inc.

BOOST WFGD SO₂ REMOVAL WITHOUT COSTLY CHEMISTRY CHANGES

THOMAS SCHRÖDER LECHLER Inc.

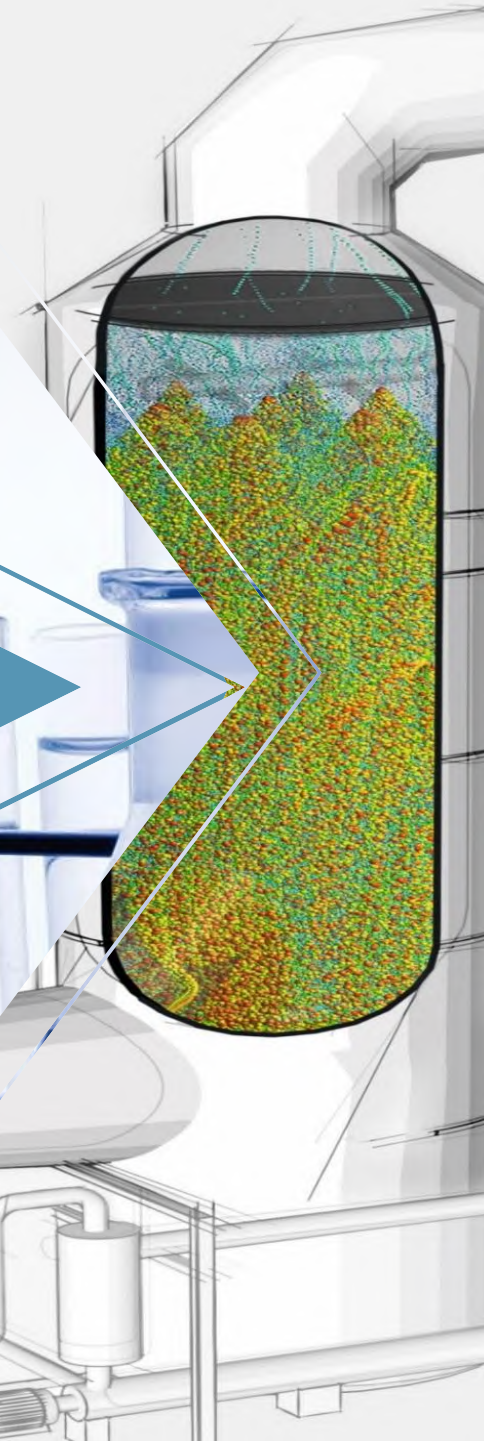


“Tougher emission laws, new global regulations, climate goals, political pressures, competition, and rising costs are reshaping the power industry.

A chemical switch — such as adding Dibasic Acid — can cost millions annually, yet a single well-engineered nozzle and/or header design upgrade can deliver comparable or better WFGD performance at a fraction of the overall lifetime cost.

This paper outlines solutions using advanced spray components for existing wet flue gas desulphurization (WFGD) systems — boosting efficiency, meeting modern standards, lowering costs, and enabling sustainable, climate-friendly operation while satisfying economic, technical, and legal requirements.

Case studies, performance data, and before/after results from thermal power plants demonstrate the gains achieved through targeted nozzle and header design changes.”



HOW RETROFIT IDEA CAME ABOUT

Emissions, sustainability, operating costs,

WHY RETROFIT?

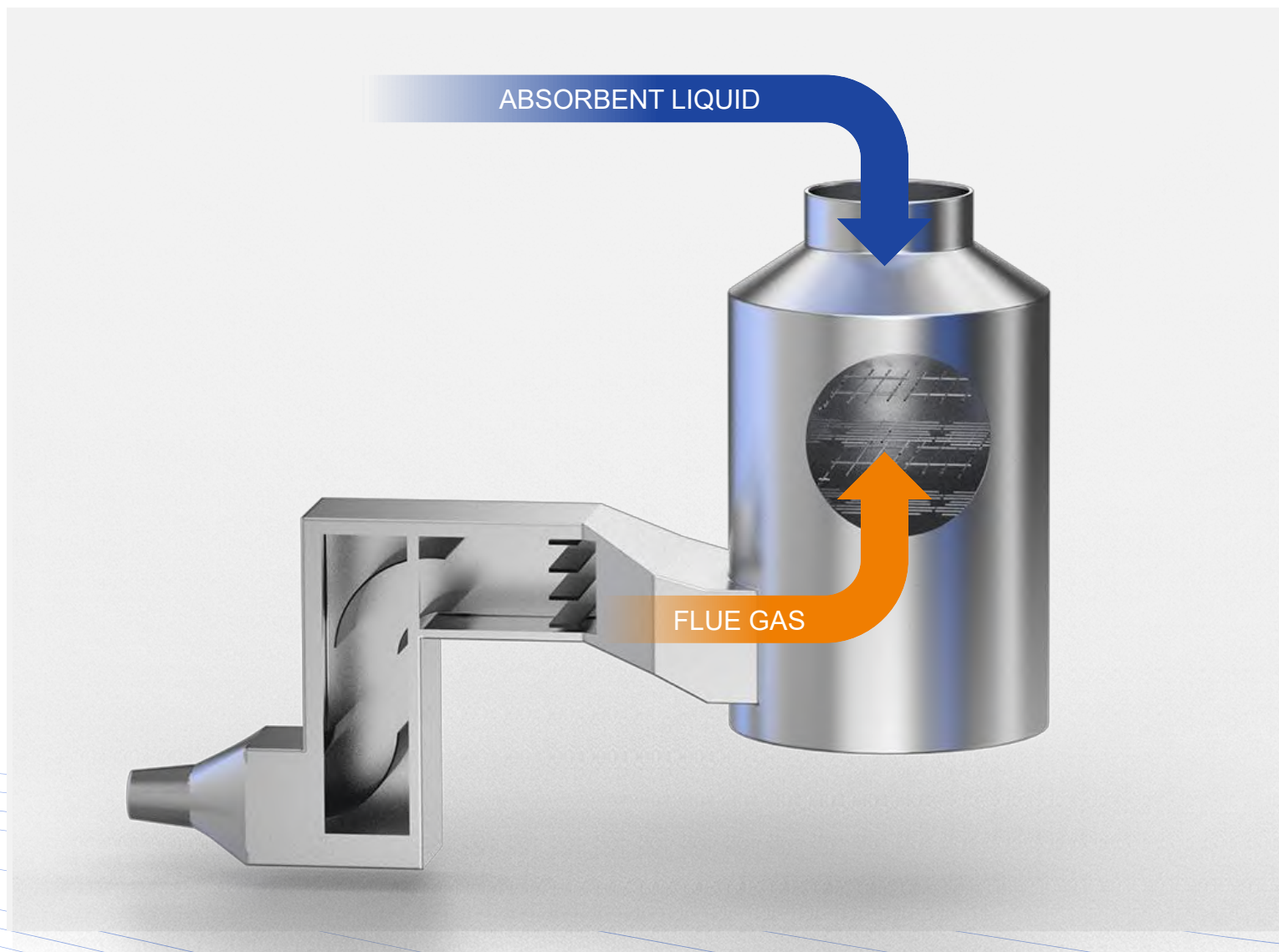
ENGINEERING
YOUR SPRAY SOLUTION



- Focus on some more efficient gas cleaning system can save millions US\$ in relation to a small investment.
- Focus on maintenance can save millions US\$ in relation to a small investment.
- High rated emission regulations must be followed to enable running the Thermal Power Plants even if it will be 500h/year only. Samples are stand-by TPPs for “grid reserve”
- Waste to Energy plants are running 24/7. All technical prospects apply like retrofit, maintenance, safe operating, cost saving,
- Political situation always change. E. g. China released 200 additional Thermal Power Plants, India changed the guidelines, what is next in U.S, Eastern Europe, Indonesia?
- The question should not be whether to get rid of electricity coming from coal but to generate it most efficient cost-wise and environmentally friendly.

How to reduce or even how to avoid chemicals and how to save resources?

Optimized scrubber performance



Pre-conditions to improve a scrubber system

- increasing the reactive surface of injected liquid
- balancing the gas distribution
- minimizing the spray loss

The injected spray influences highly the process performance due to

- guidance of gas distribution
- droplet size
- relative velocity liquid to gas
- secondary atomization

There are plenty of options to handle these parameters by adjustment of nozzle configuration and nozzle types in respect to

- comply with even stricter emissions restrictions
- reduce operating costs and maintenance at the same time
- **Comply with resource-saving!**

These days even more important

In the benefit arguments presented to the plant operator, its primarily address our claim regarding environmental awareness and resource saving. So, in the case of an FGD optimization, not primarily the reduction of operating costs and in case, maintenance costs, but also the potential saving of the limited resource water.

An optimized Wet FGD system allows the L/G, that is, the washing water quantity to flue gas, to be significantly reduced and/or in this case the reduction of water consumption for cleaning deposits.

.....while water savings goes hand in hand with reducing of operating and maintenance costs.

As a result, most of retrofits highly benefit water secure future

EVERY SCRUBBER SYSTEM CAN BE IMPROVED

IF: YOU CAN REDUCE MAINTENANCE AND KEEP THE SPRAY PERFORMANCE

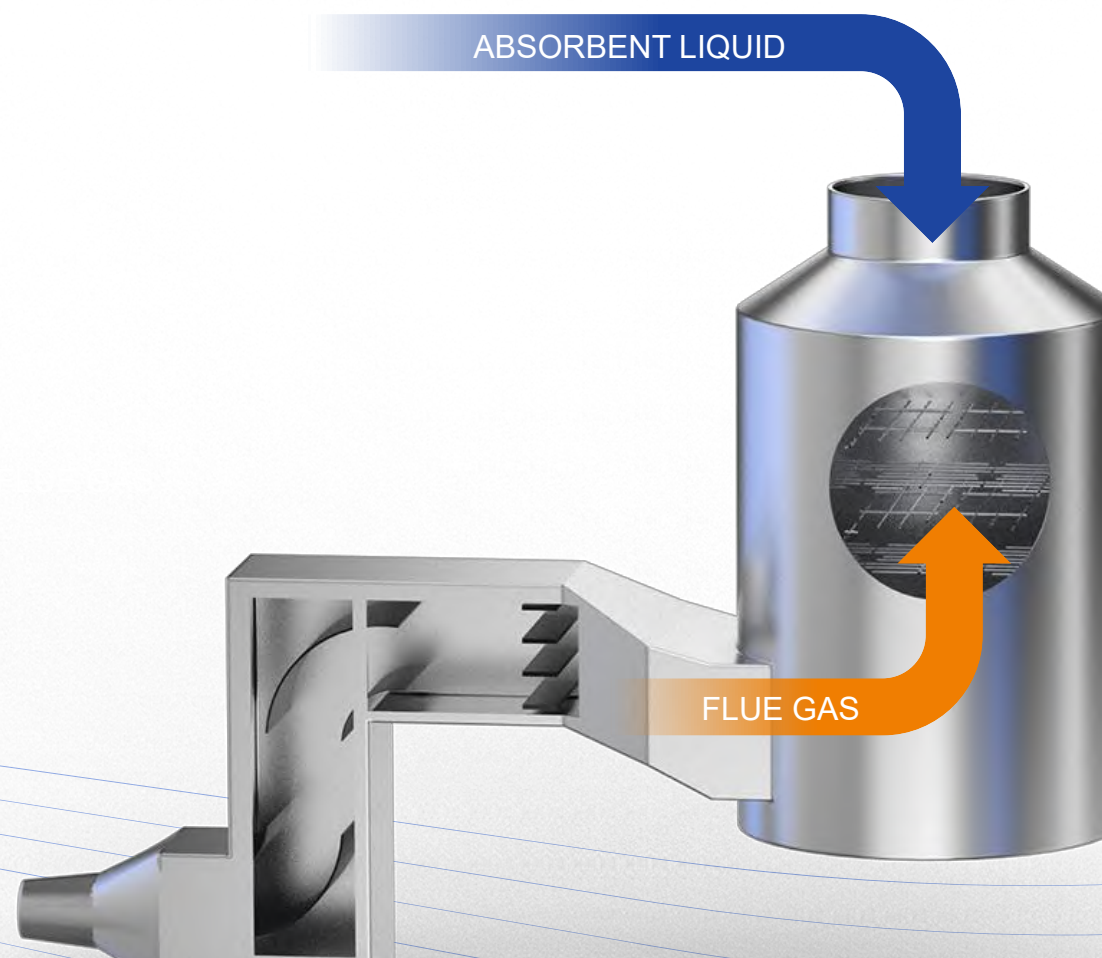
IF: YOU CAN INCREASE THE REACTIVE SURFACE OF THE INJECTED LIQUID

IF: YOU CAN BALANCE THE GAS DISTRIBUTION

The **components** influence highly the process performance due to several features of the spray.

Experience and knowledge about these features are an essential base to engineer customized solutions.

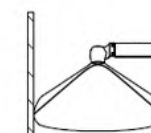
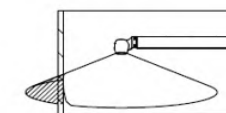
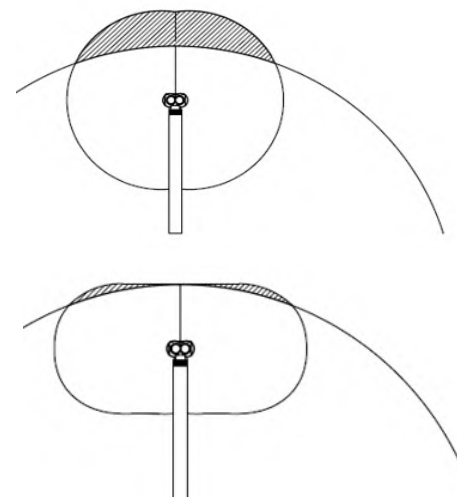
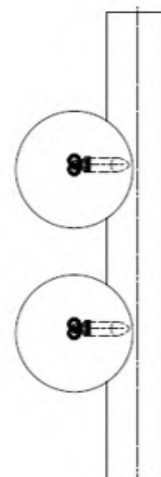
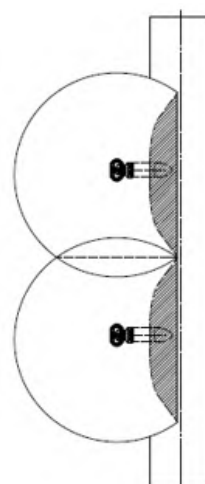
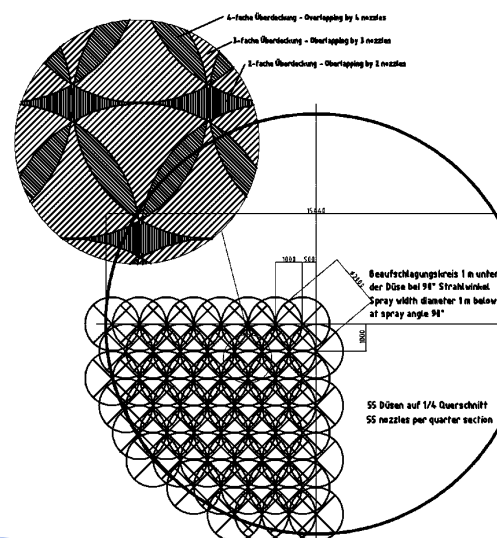
The presented solutions allow to follow stricter regulations coming with BREF limitations in line with the necessary need for operational cost reduction.



CONVENTIONAL SPRAY SHAPE

Standard full and hollow cone with round spray pattern

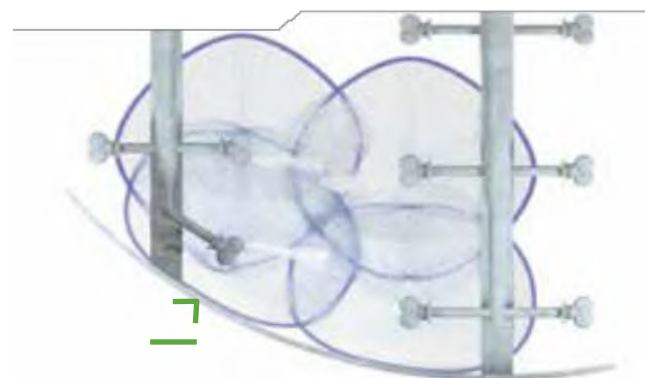
- Exposed to gas leakage
- Exposed to clogging (full cone nozzles)
- Compromise on SMD_{32} when using full cone instead of hollow cone nozzles
- High spray impact on scrubber wall, piping and support construction thus exposed to maintenance costs
- Adverse L/G performance as a significant fraction of liquid is wasted via wall impingement



ADJUSTABLE SPRAY SHAPE

Customized engineered spray design follows the individual scrubber design

- Improved mass transfer due to more available reactivity surface for the process
- Improved L/G performance as more liquid is available for the process instead of being wasted via wall impingement.
- Pre-condition for highly reduced gas and dust leakage
- Hollow cone shape leads to optimized free passages (less clogging)
- No compromise on SMD_{32} in comparison to full cone nozzles
- Design of angle at wall side can reduce impact of spray against the scrubber wall significant.



The TwinAbsorbPRO® series features in all directions adjustable hollow or full cone spray pattern. This allows nozzles close to the wall and close to piping to be adjusted hence their spray cone follows the scrubber walls and piping gentle, avoids erosion and prevents loss of process enhancing reaction surface

OPTIMIZED SPRAY SHAPE

TwinAbsorbPRO®-02_protecting-walls

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ADJUSTABLE SPRAY SHAPE / TWINABSORB-PRO[®]

Spray Pictures TwinAbsorb_PRO[®] Nozzles



35° spray
angle

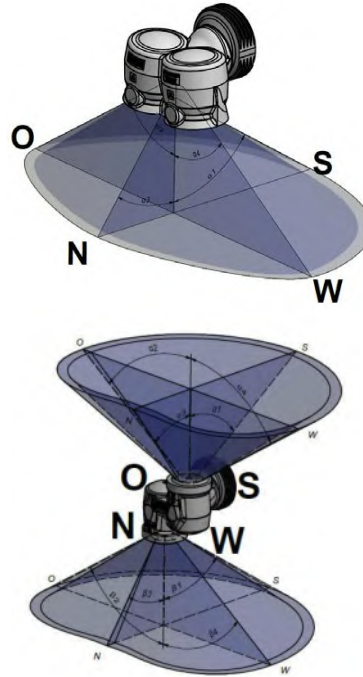
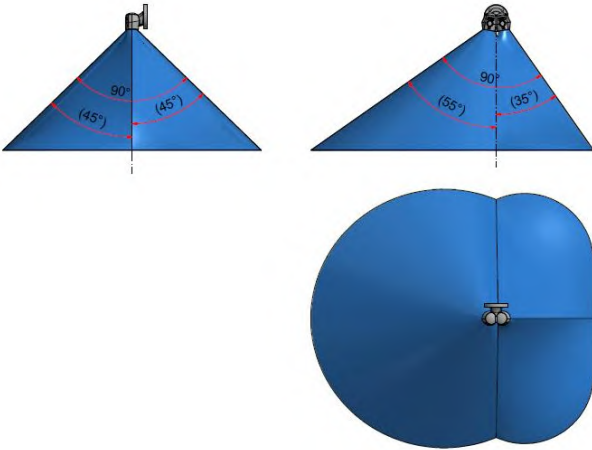
55° spray
angle



55° spray
angle

35° spray
angle

HOW TO DESCRIBE THE SHAPE



*NEW TwinAbsorbPro®
patented*

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The spray angle of the TwinAbsorbPRO® can be adjusted in all directions between 35 and 55°. Standard operating pressure is between 0.5 and 2 bar. Other design data are available on request. The flow rate depends on the application. The connection to the piping is available as thread, flange, clamp, glue or laminate connection.

SPRAY NOZZLES

Small component – high influence on:

Wall Erosion



Solution

adjust spray shape



SPRAY NOZZLES

Small component – high influence on:

Efficiency
adjust spray
distribution



NEW TwinAbsorbPro[®]
patented



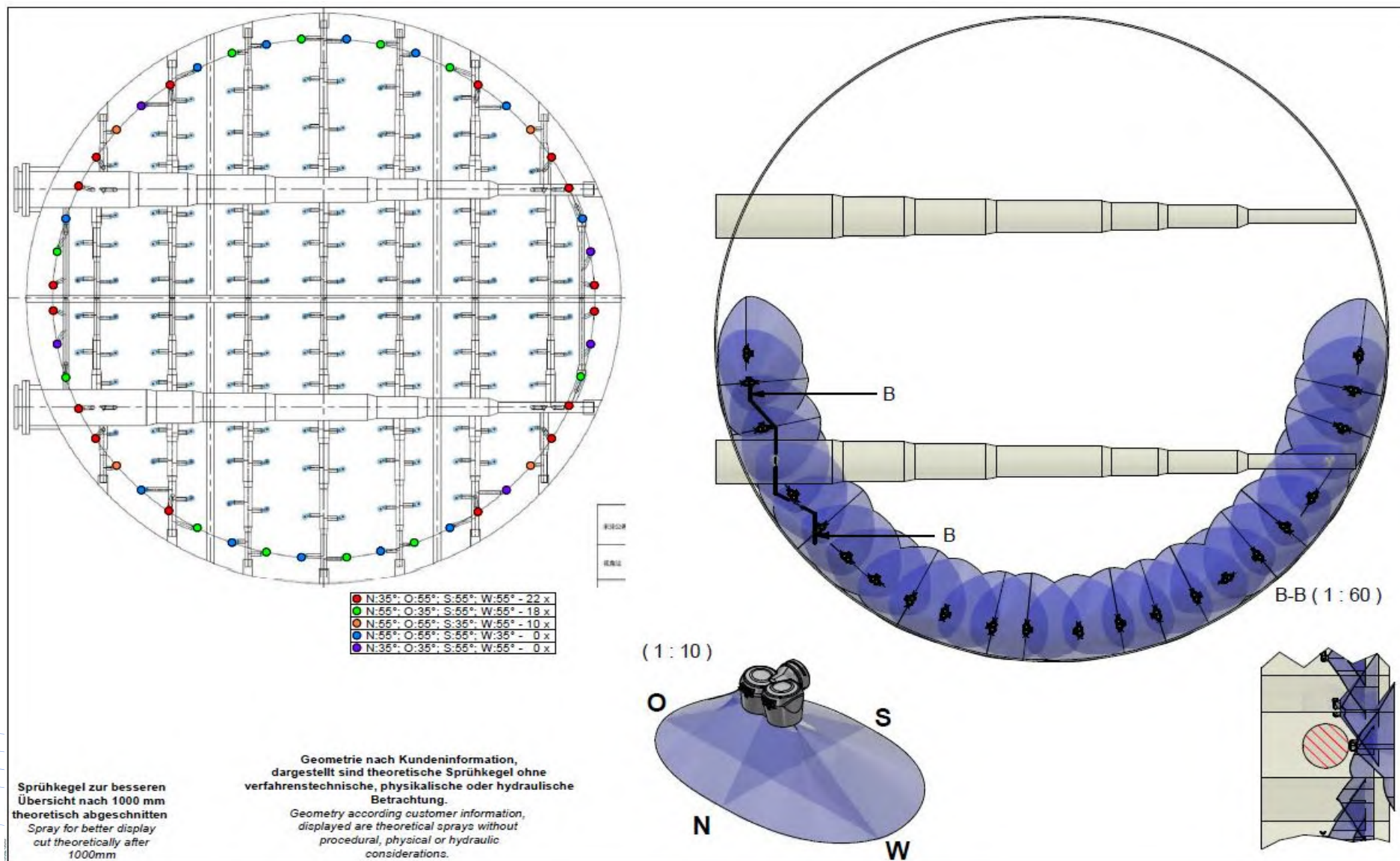
TwinAbsorbPRO[®]-EH



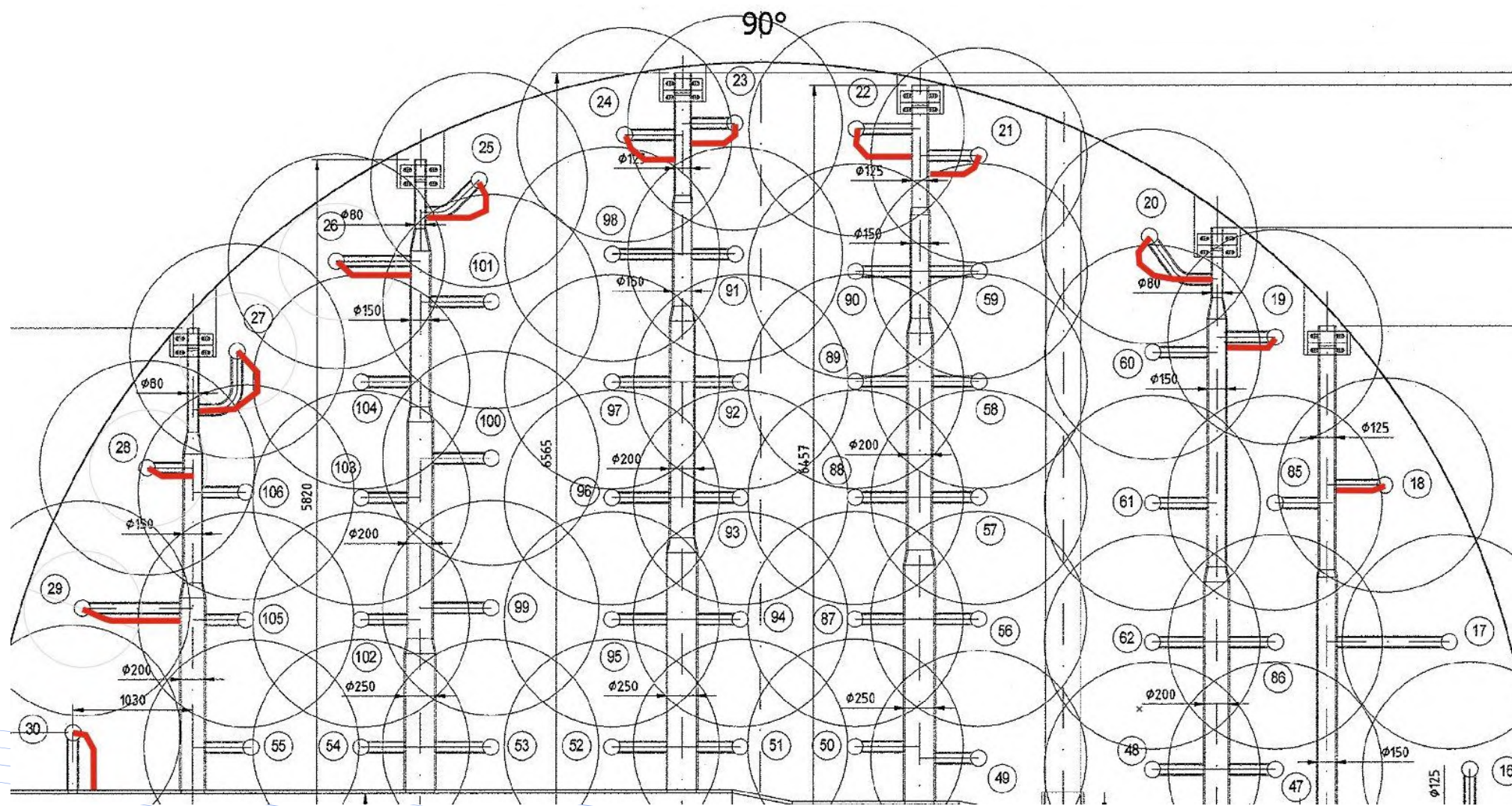
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CASE STUDY INSTALLATION AROUND WALL



CASE STUDY INSTALLATION AROUND WALL



THE TWIN-ABSORB-PRO® SERIES

THE PATENTED FUNCTION OF IN ALL DIRECTIONS ADJUSTABLE SPRAY PATTERNS.

PROdeSOx: Improved DeSOx due to higher availability, less liquid loss at wall, smaller drop size, improved secondary atomization.

PROdeDust: As well DeDusting can be improved. First plants operate already successful.

PROtective: Less impact onto the wall (e.g. rubber lining) compared to standard hollow cone nozzles with standard spray pattern.

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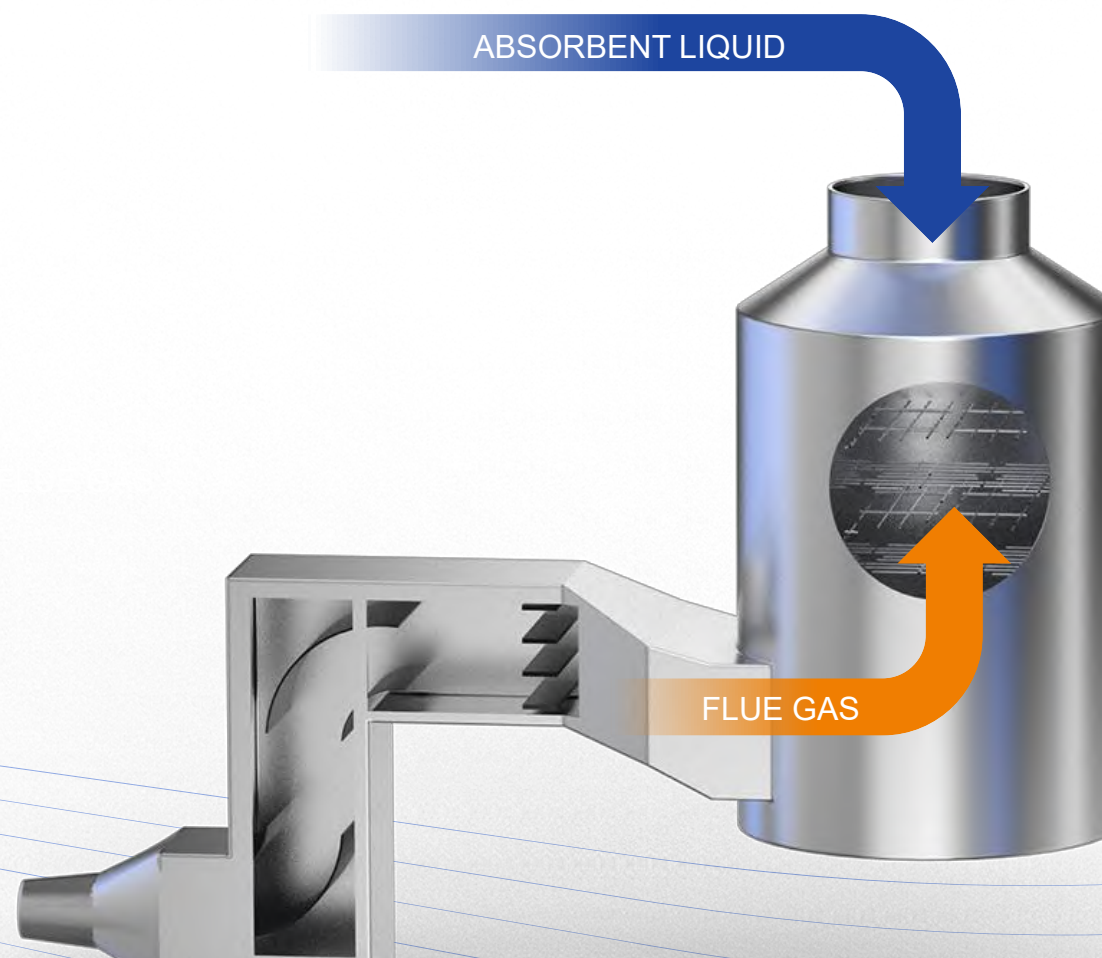
IF: YOU CAN INCREASE THE REACTIVITY SURFACE OF THE INJECTED LIQUID

IF: YOU CAN BALANCE THE GAS DISTRIBUTION

The **components** influence highly the process performance due to several features of spray.

Experience and knowledge about these features are an essential base to engineer customized solutions.

The presented solutions allow to follow stricter regulations coming with BREF limitations in line with the necessary need for operational cost reduction.



THE REASON TO USE SPRAY NOZZLES

Process Engineers calculate the necessary lime slurry/liquid to clean the raw gas (l/g ratio)

They also calculate necessary reactivity surface (SMD/D32) on which the process will work

Nozzle task is to turn liquid/slurry into surface means into droplets

The smaller the droplets the higher the necessary pressure

But the smaller the droplets the bigger the specific surface

How to generate small droplets which goes with large reactivity surface without high energy input?

THE TASK OF THE DROPS/DROPLETS

The reaction between raw gas and lime slurry happens at the droplet surface

Immediately the droplet generates a shell

The shell stops further reaction of raw gas with lime slurry

As soon as the shell can get opened the process start again

How to enhance the process?

THE PROCESS

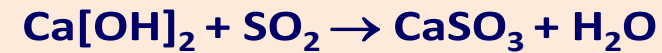


Chemical reaction in wet FGD process the reaction is very quick

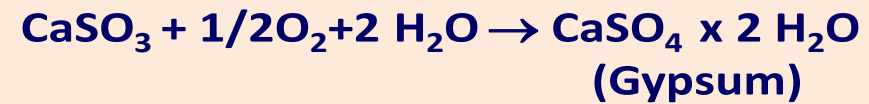
Limestone-Scrubbing (pH = 5,0 - 6,0)



Lime-Scrubbing (< pH = 5,5)



Oxidation Step (pH = 4,0 - 5,0)



Question

**HOW MANY TIMES
DOES A DROPLET HAS TO PASS THROUGH THE
SCRUBBER
TO PROVIDE ITS FULL POTENTIAL FOR THE PROCESS?
HOW TO TURN INTO BENEFIT?**

ABOUT ATOMIZATION BY COLLISION



SPRAY NOZZLES

Small component – high influence on:

- Nozzles can increase specific reactive surface
- Enable enhancing reactivity of injected absorbent
- Enable multiplying collision areas by using equilateral spray cones

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Reactivity
surface
increase it

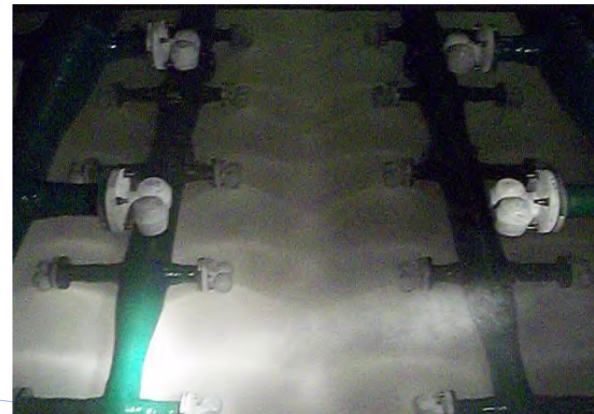
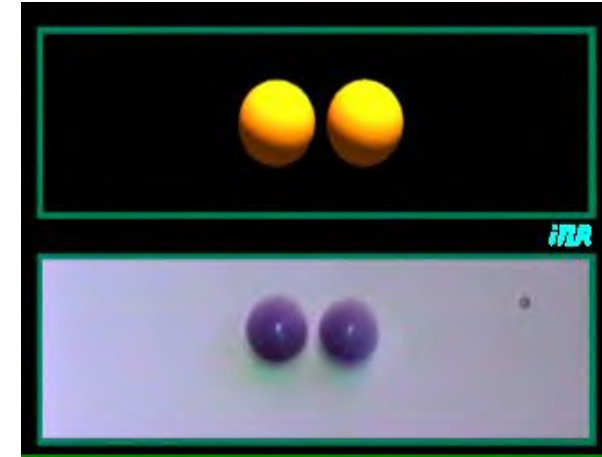
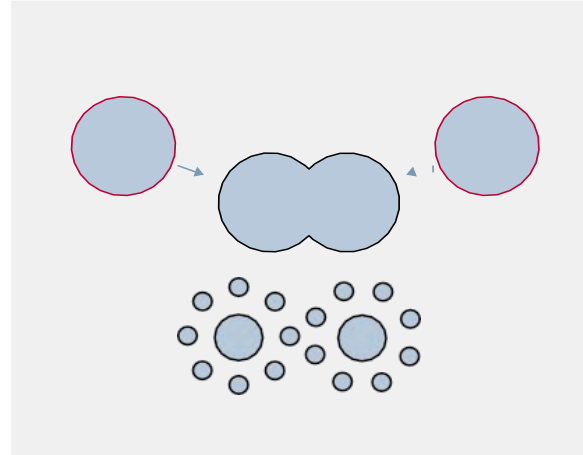
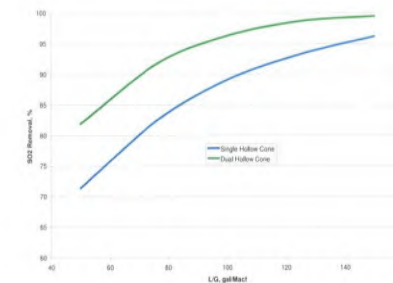
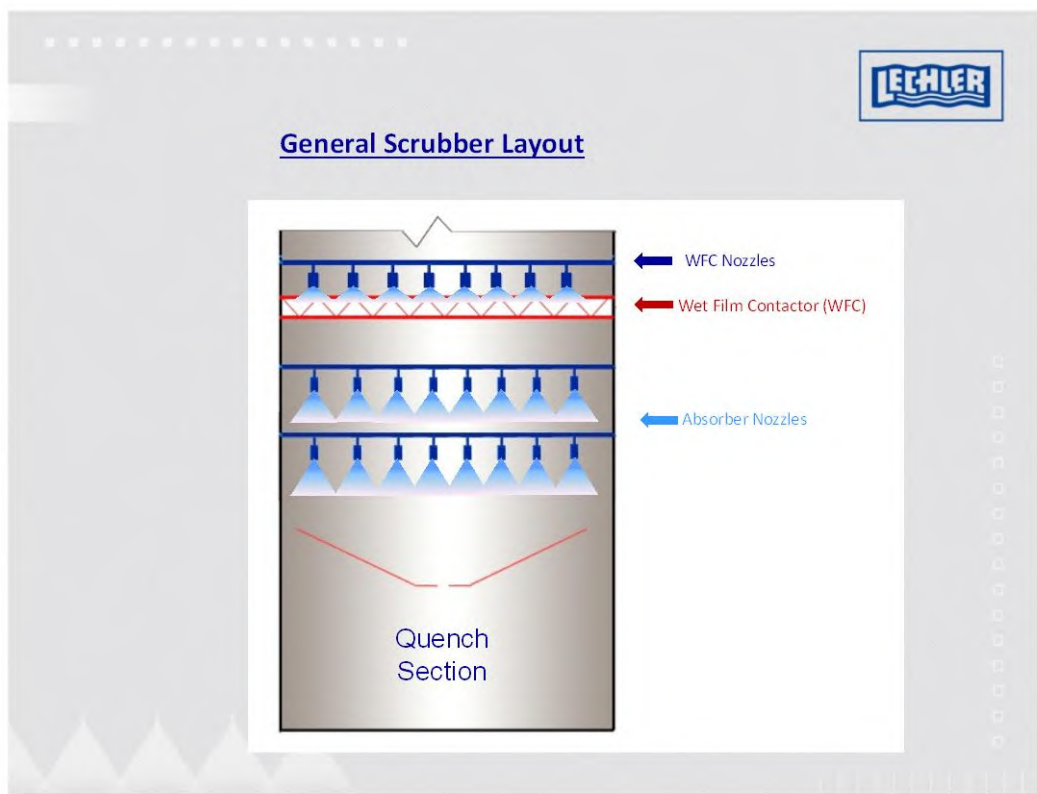


Figure 3: Predicted Removal for SHC and DHC Spray Nozzles as a Function of L/G

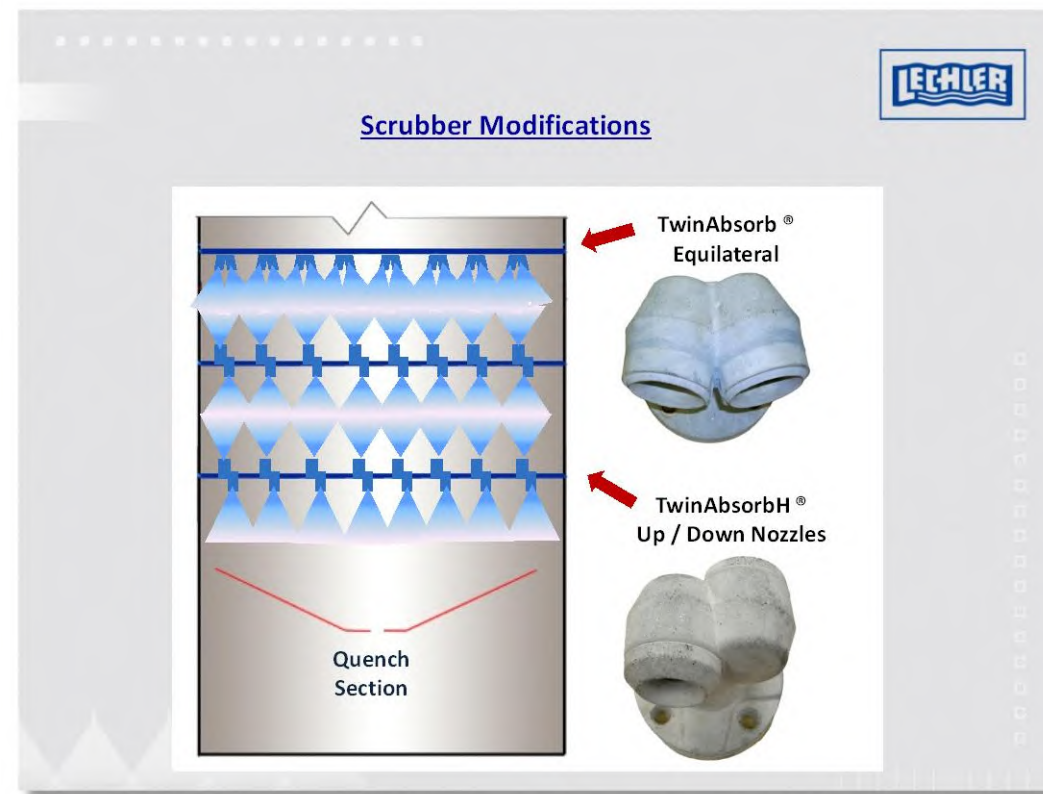


SCRUBBER MODIFICATION BY HYDRAULIC SPRAY LEVEL

Before



After



EVERY SCRUBBER SYSTEM CAN BE IMPROVED

IF: YOU CAN REDUCE MAINTENANCE AND KEEP THE SPRAY PERFORMANCE

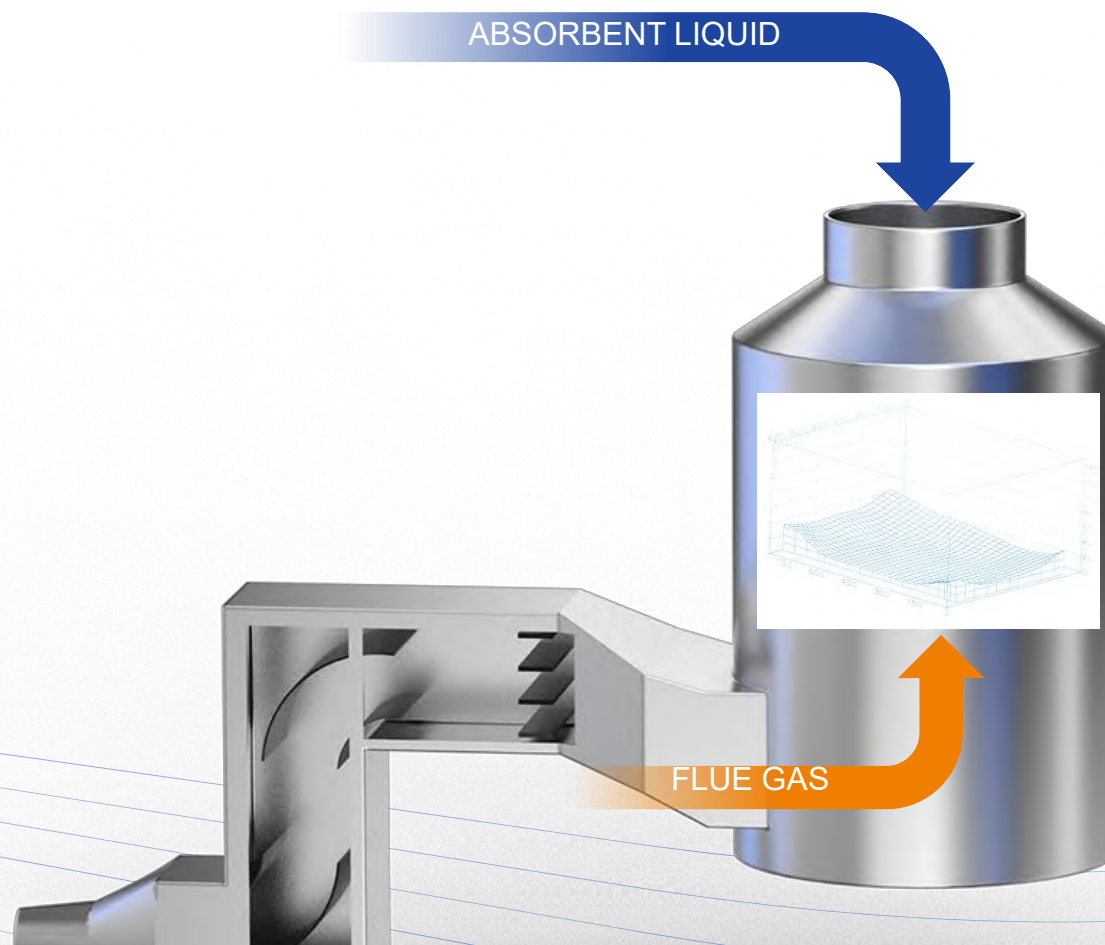
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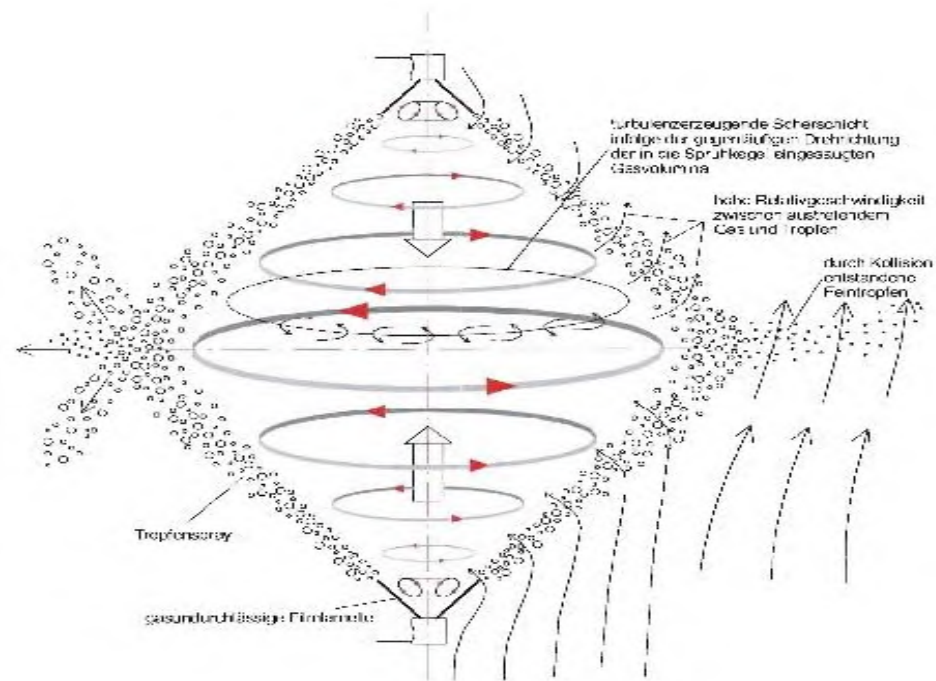
How to support an even gas distribution?

JET PUMP EFFECTS

- Nozzles work like a pump
- They influence spray turbulence
- They influence relative velocity
- They influence Δp in combination with tray solutions



Lechler Test Lab Metzingen - Germany



Outdoor test shows study with free rotating impeller

COUNTER ROTATION

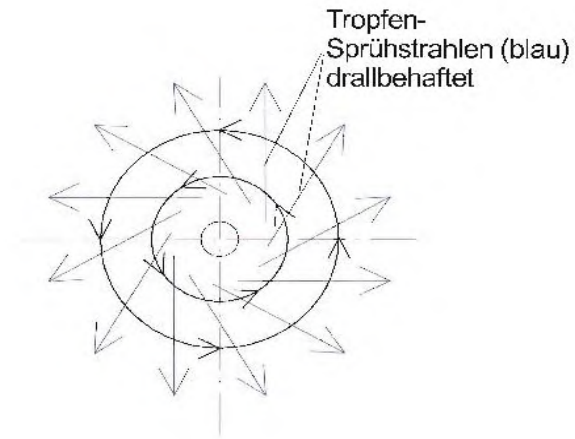
Small component – high influence on:

- TwinAbsorb Nozzles can increase relative velocity
- Enable supporting even gas distribution
- Enable increasing turbulence due to counter rotating sprays

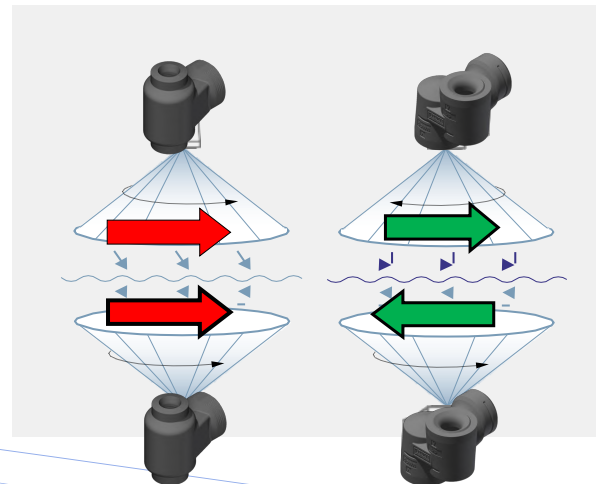
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YOUR SPRAY SOLUTION



Gas
distribution
balance it



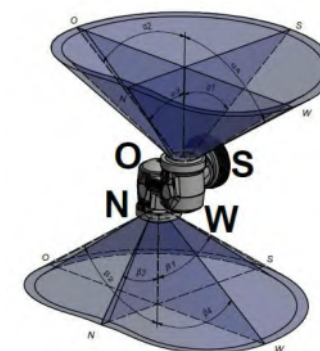
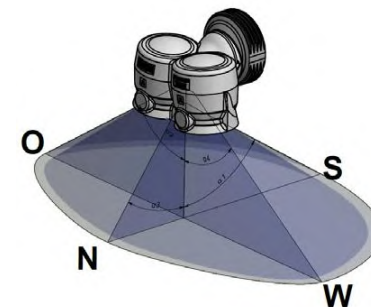
Standard



TwinAbsorb

RETROFIT SAMPLE

THERMAL POWER PLANT IN THE U.S.





Efficiency Improvements and Operational Cost Reductions of a Dual Loop Wet FGD Scrubber at Muscatine Power & Water Using TwinAbsorb® Nozzle Technology



Muscatine Power & Water Background

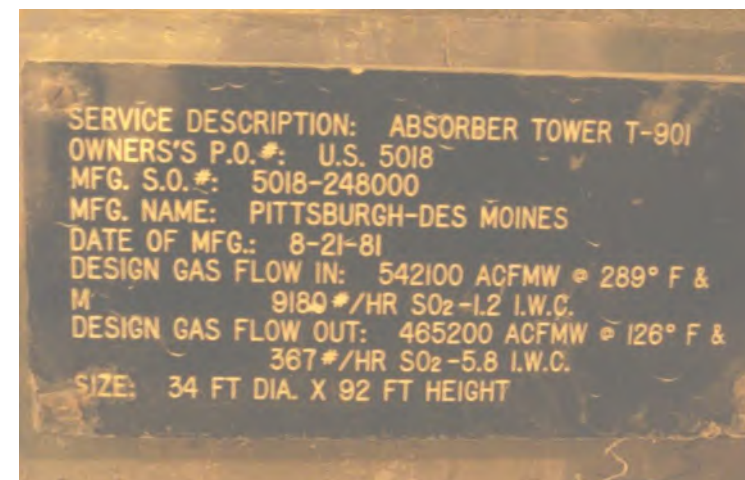


**Located on the eastern
border of Iowa on the
Mississippi River**

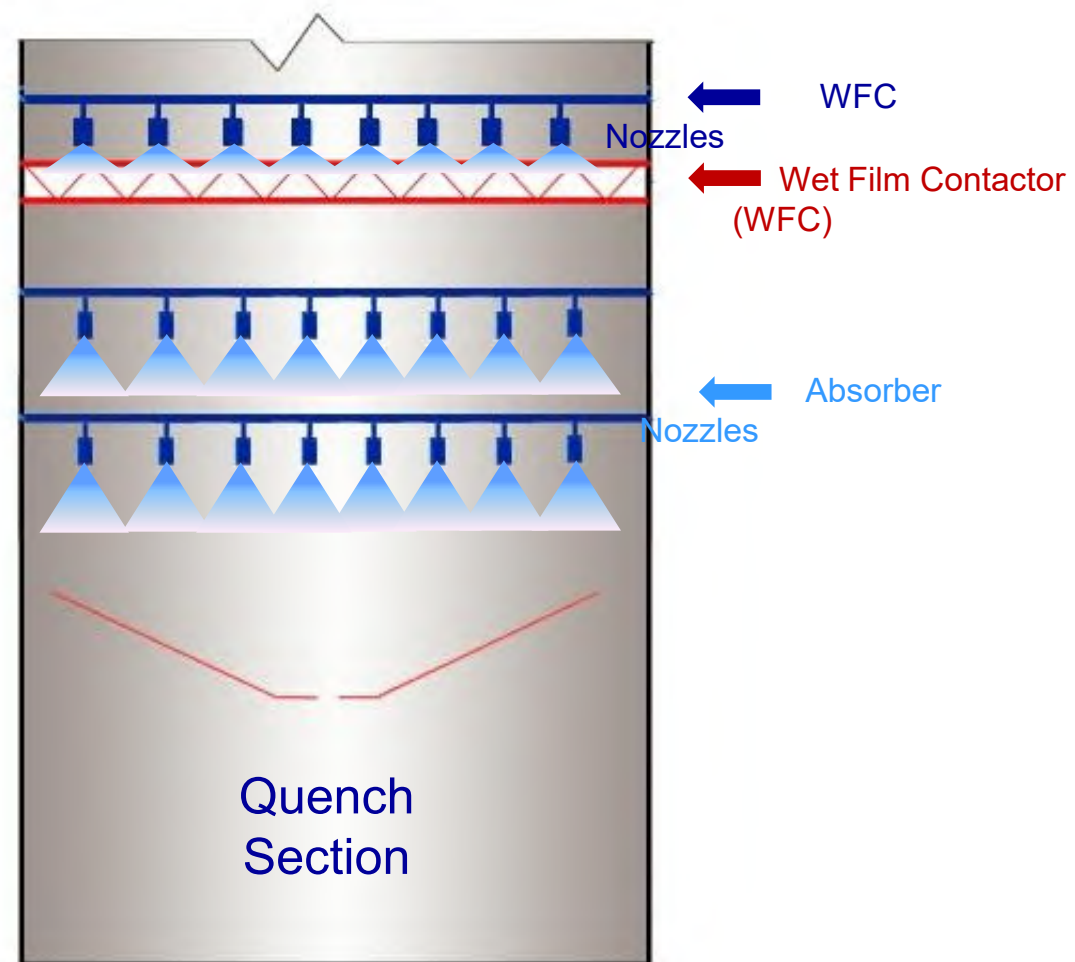


Boiler/Scrubber Information

- **175.5 MW Nameplate Generating Capacity**
- **(2) Research-Cottrell Dual Loop Scrubbers**
 - **One operational, one standby**



General Scrubber Layout

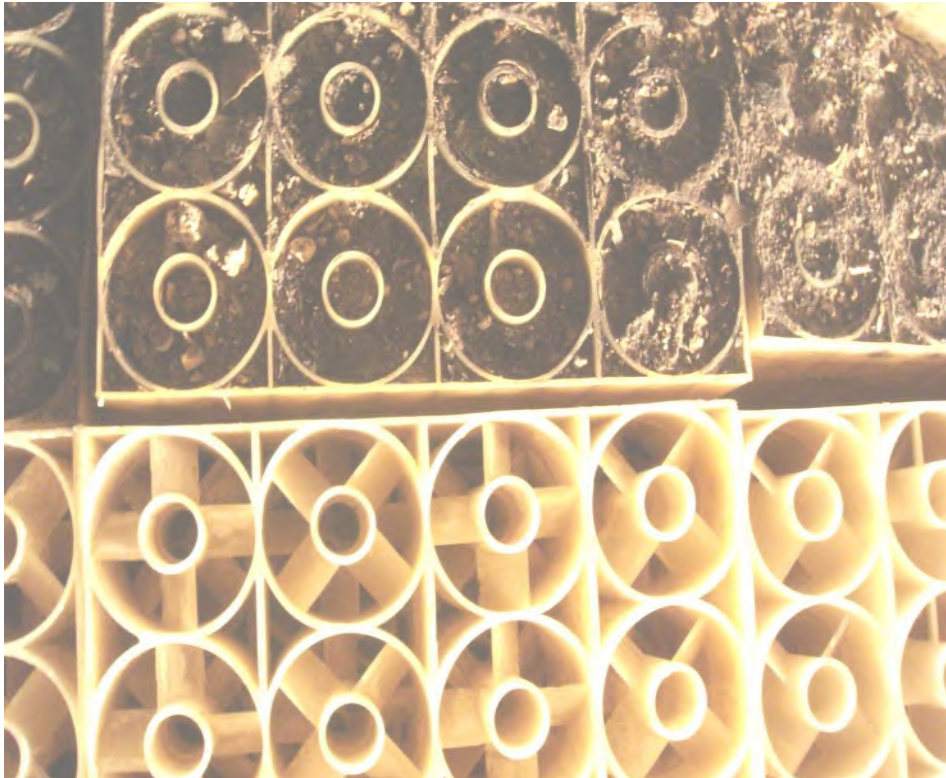


Wet Film Contactor (WFC)



- Prone to plug
- High pressure drop for ID Fan
- Required 2.5% open bypass
- Expensive - \$300,000 for complete replacement

Wet Film Contactor (WFC)



▪ **Plugged WFC**

▪ **Clean WFC**

Outdated Nozzle Technology



Nozzles Above WFC

- Prone to pluggage
- Minimal gas coverage
- Large droplets not ideal for SO_2 removal, however good for wetting of the packed bed

Operational Issues

- **High fan requirements**
- **High maintenance costs**
- **Frequent unplanned outages**
- **Obsolete nozzle technology**
- **Limited SO₂ removal**

Goals of Retrofit

- **Eliminate need of WFC**
- **Decrease outage frequency**
- **Reduce maintenance costs**
- **Reduce operational costs**

Goals of Retrofit

- Improve nozzle technology
- Improve SO₂ removal
- Seamless change to low sulfur coal

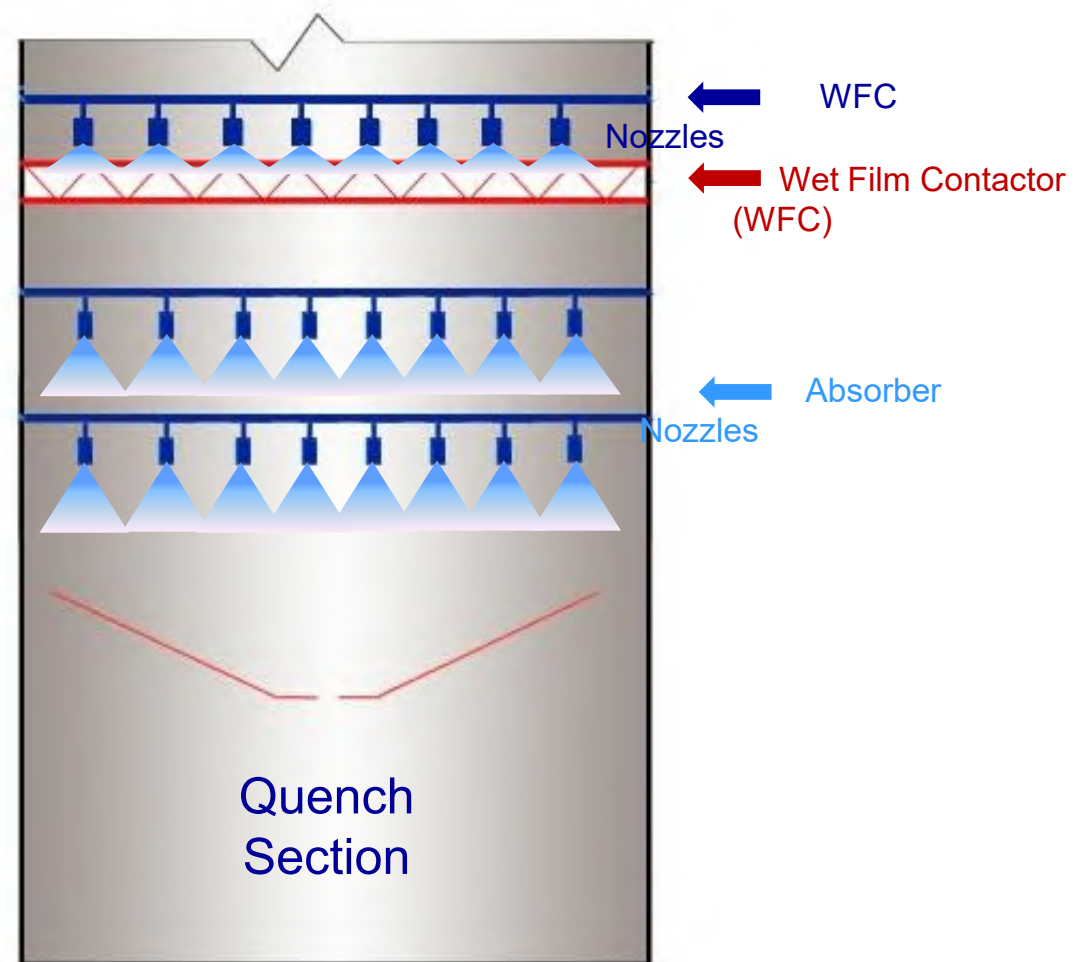
(.60% to .29% S) > 1200 – 600 mg/Nm³ SO₂

(1% S > 2000 mg/Nm³ SO₂) / 15 % > 90 mg/Nm³ / 5 % 30 mg/Nm³

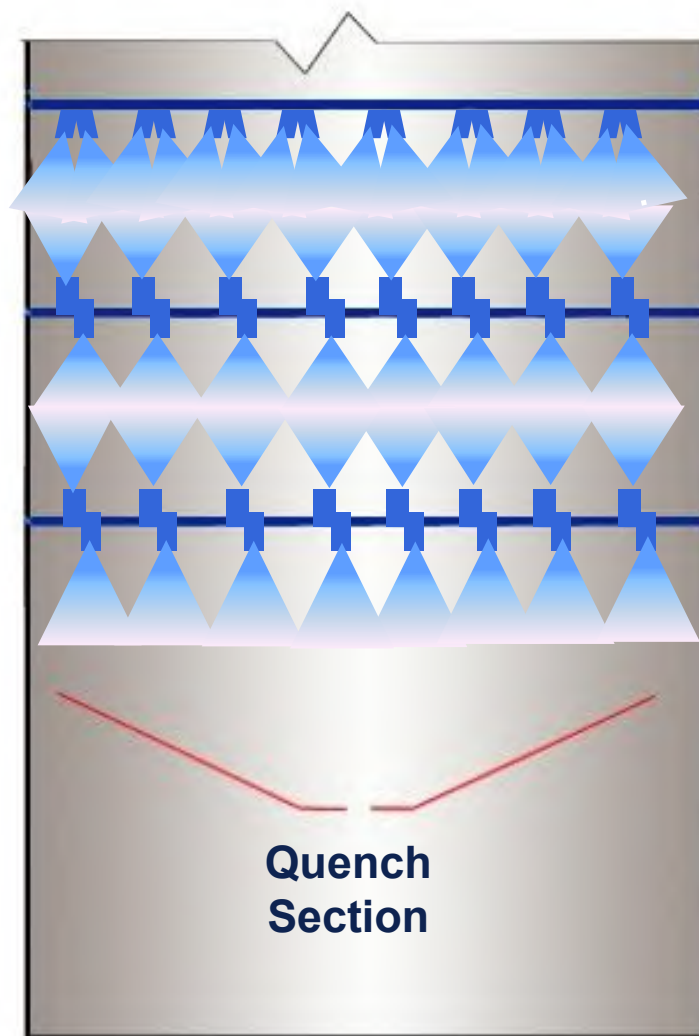
Scrubber improvement options

- Increase L/G
- Install Wall Plates
- Use Acid Enhancement
- Install Trays
- Improve Nozzle Technology

General Scrubber Layout



Scrubber Modifications



← **TwinAbsorb®
Equilateral**



← **TwinAbsorbH®
Up / Down Nozzles**



Rotated Headers



Elimination of WFC



Nozzles Above WFC

- Improved Gas Flow
- Full Gas Coverage
- Optimum droplets for SO₂ removal
- Increased droplets and surface area for mass transfer

Results

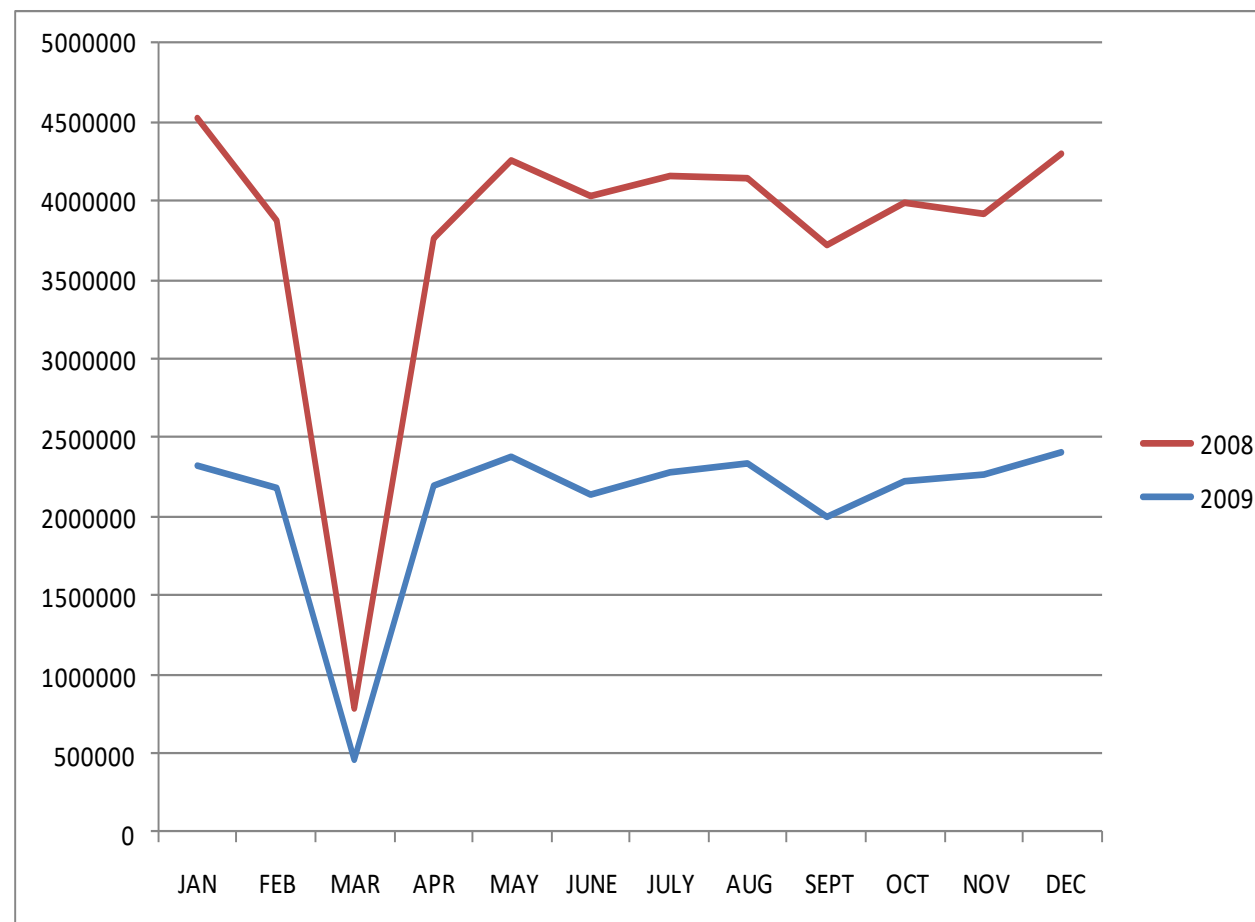
- **WFC Removed**
- **Reduced outage frequency (2 year planned)**
- **Maintenance costs reduced**
- **Operational costs reduced**
- **SO₂ removal (98-99%)**
- **Bypass damper completely closed**
- **Increased latitude on coal quality**

Energy Reductions

- **Fan input power decreased from 778 KW to 335 KW**
- **Decreased limestone usage**
- **Decreased ball mill energy usage**
- **Decreased waste equipment usage**
- **Decreased pump energy**

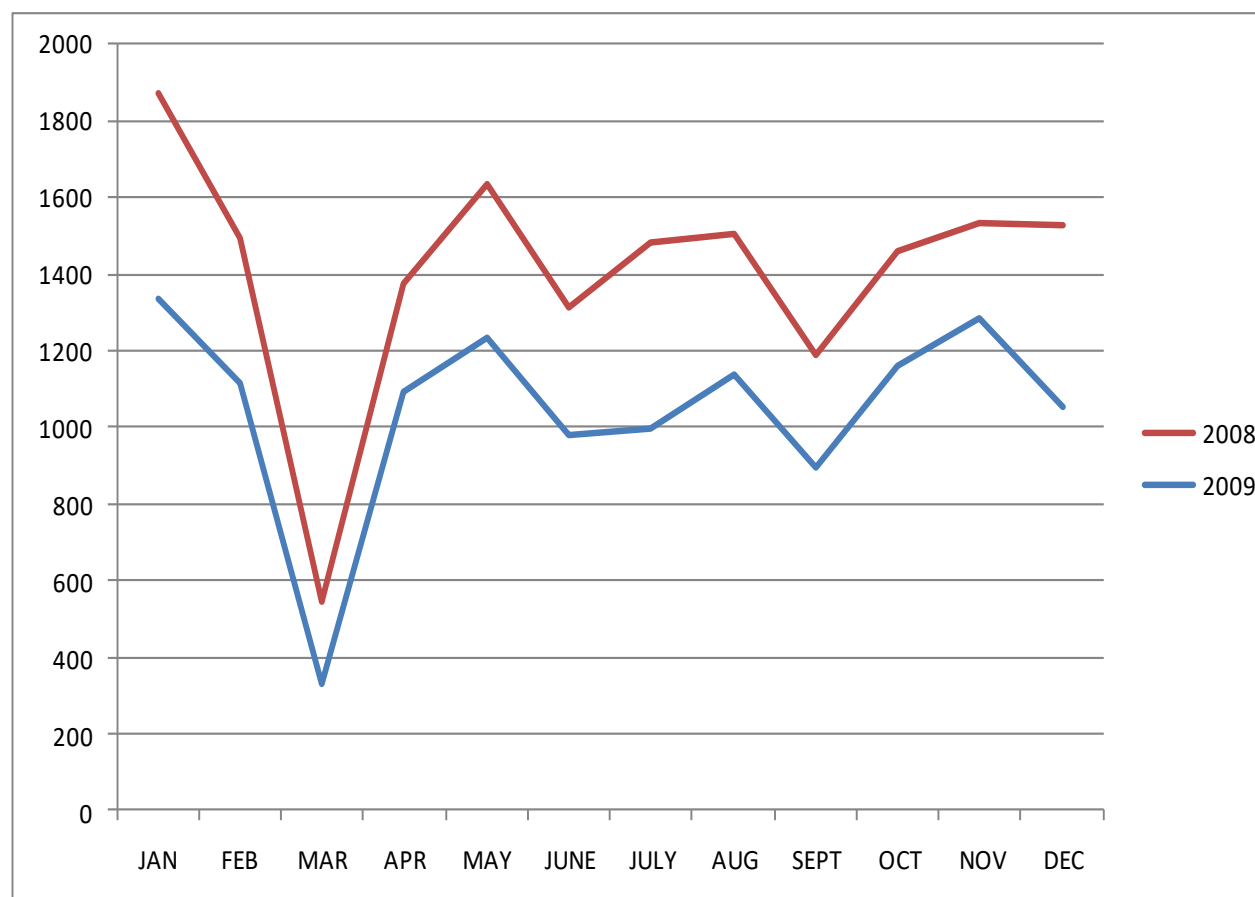
Energy Reductions

kwh



Limestone Usage

Tons



Cost Savings!

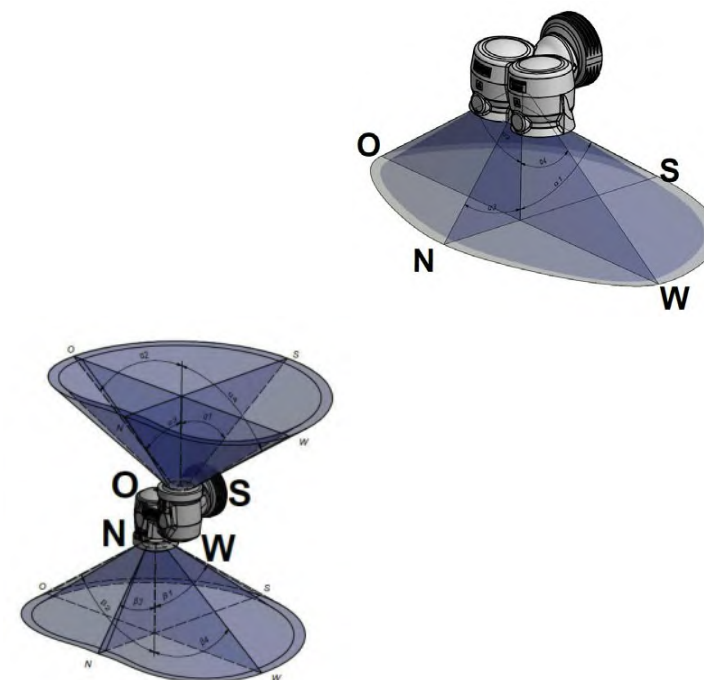
- **\$ 1,226,000/year energy cost savings**
- **\$ 300,000 packing replacement no longer required**
- **\$ 41,000/year pump savings**
- **Water savings**

RETROFIT TPP BELCHATOW

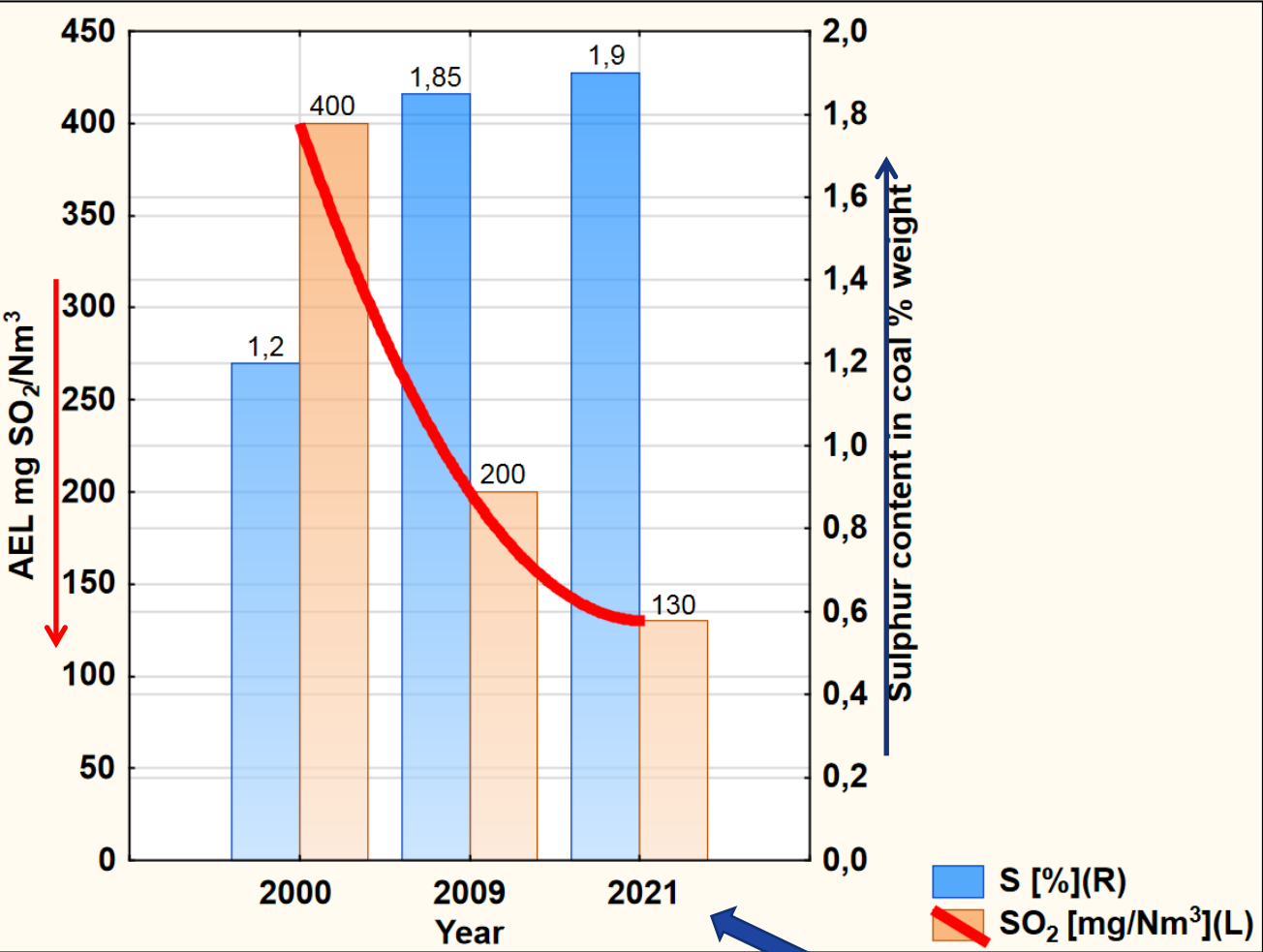
CO-AUDITOR

RAFAKO S.A.

Dip.-Ing. Jerzy Mazurek



Genesis of the project: Increase in sulphur content in fuel due to reduction of SO₂ emission limit (AEL)



Belchatow Power Plant is the largest lignite-fired power unit both in Poland and in Europe.

Total electrical power of boiler units operated in Belchatow PS is 4732 MW_e.

TARGET:

	AEL [mg/Nm ³]		Eff. SO ₂ removal	
Before	200		98,0%	
After	130	-35%	98,7%	+0,7%

2021: Start of Implementation Best Available Techniques Reference Document for the Large Combustion Plants (BAT Conclusion)

Technology used for increase efficiency SO₂ removal

Unit No Unit Power Absorber diameter	Year of start FGD operation (basic project)	Technology for increase eff. SO ₂ removal		Date of commissioning after modernization
		New concept and new nozzles for spray level	Additional used technology	
7 / 390 MW / 15,7 m	2003	TwinAbsorb-EH, -H	FGD_2.0 (RAFAKO) Research project	12.2017
9 / 390 MW / 15,7 m	2003	TwinAbsorb-EV, -H, -EH	FGD_2.0 (RAFAKO)	09.2020
10 / 390 MW / 18,7 m	1994	TwinAbsorb-EV, -H, -EH	FGD_2.0 (RAFAKO)	09.2020
5 / 380 MW / 15,7 m	2000	TwinAbsorb-EV, -H, -EH	FGD_2.0 (RAFAKO)	12.2020
6 / 394 MW / 15,7 m	2000	TwinAbsorb -EV, -H, -EH	FGD_2.0 (RAFAKO)	12.2020
12 / 390 MW /18,7 m	1996	TwinAbsorb-EH, -H TwinAbsorbPRO	FGD_2.0 (RAFAKO)	10.2021
11 / 390 MW / 18,7 m	1996	TwinAbsorb-EH, -H TwinAbsorbPRO	FGD_2.0 (RAFAKO)	10.2021
3 / 380 MW/ 17,0 m	2007	TwinAbsorb-EV, -H, -EH	FGD_2.0 (RAFAKO)	11.2021
8 / 390 MW / 18,7 m	1995	TwinAbsorb-EV, -H, -EH	FGD_2.0 (RAFAKO)	11.2021
4 / 380 MW / 17,0 m	2007	TwinAbsorb-EV, -H, -EH	FGD_2.0 (RAFAKO)	12.2021
14 / 858 M / 2x16,0m	2011	TwinAbsorb-EH, -H TwinAbsorbPRO	-	Planned 12.2023

Spray levels modernization concept and FGD_2.0 process technology

Photos for unit 7 after modernization

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Spray levels modernization concept

Example for unit 7

Generally: Individual design for each absorber

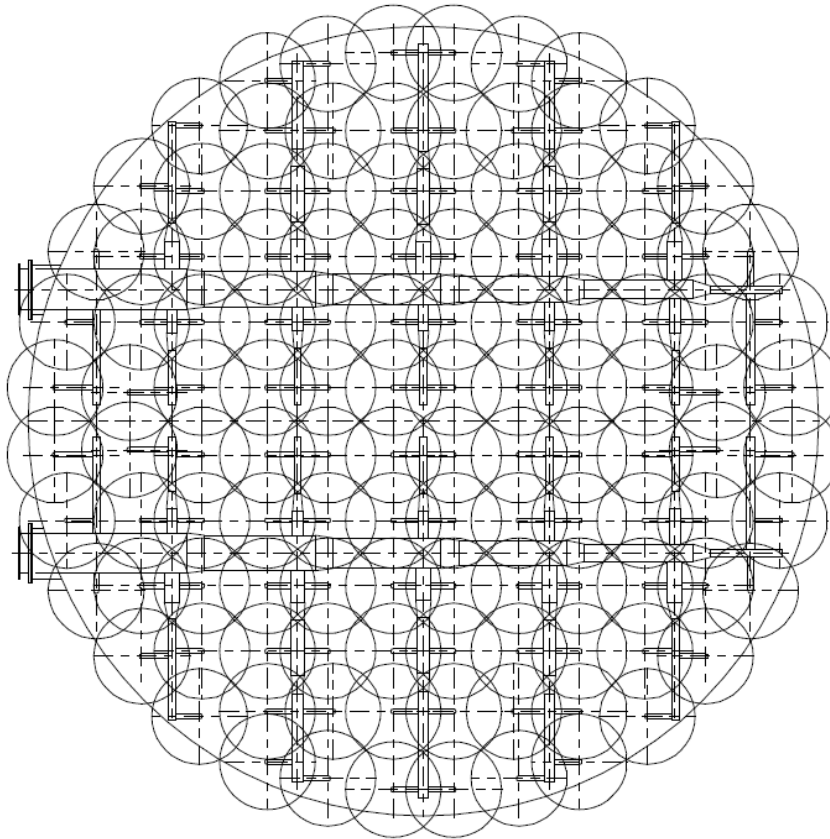
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Before

...

After

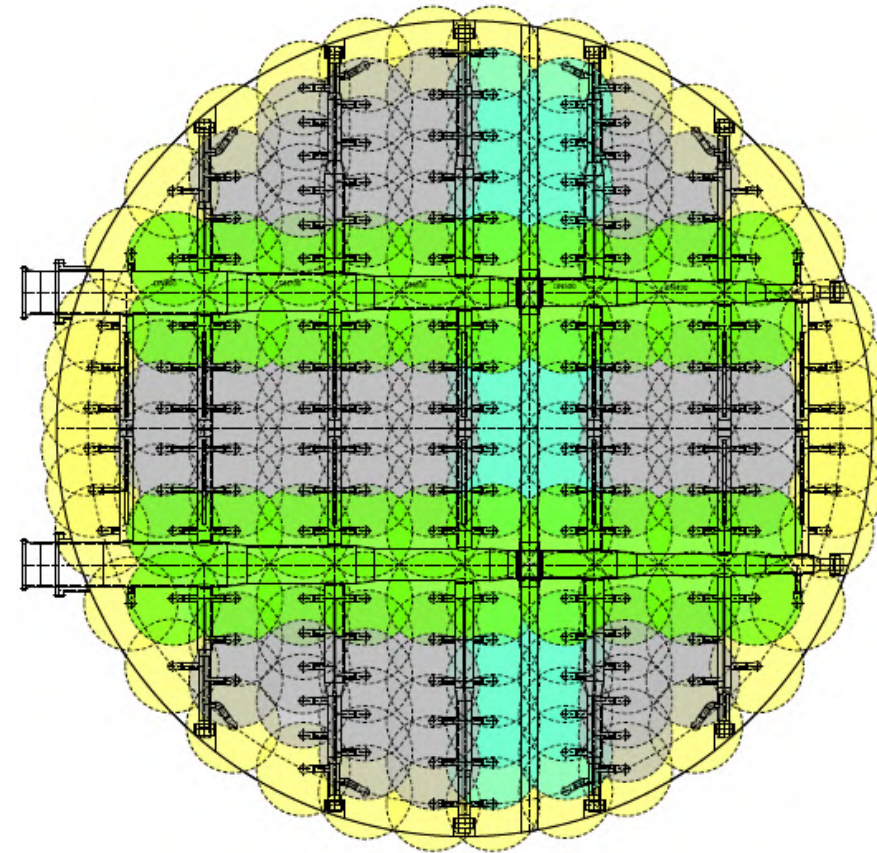


Quantity of nozzles per one level: **120 pc**

Types of nozzle: **2**

Nozzle capacity: **1583 l/min**

Connection type: lamination DN125



Quantity of nozzles per one level: **172 pc**

Types of nozzle: **5**

Nozzle capacity: **1105 l/min**

Connection type: Victaulic, DN100

Visualization of the effects of absorber modernization on the example of unit 7.

Synergistic effect of using new nozzles and FGD_2.0 process technology.

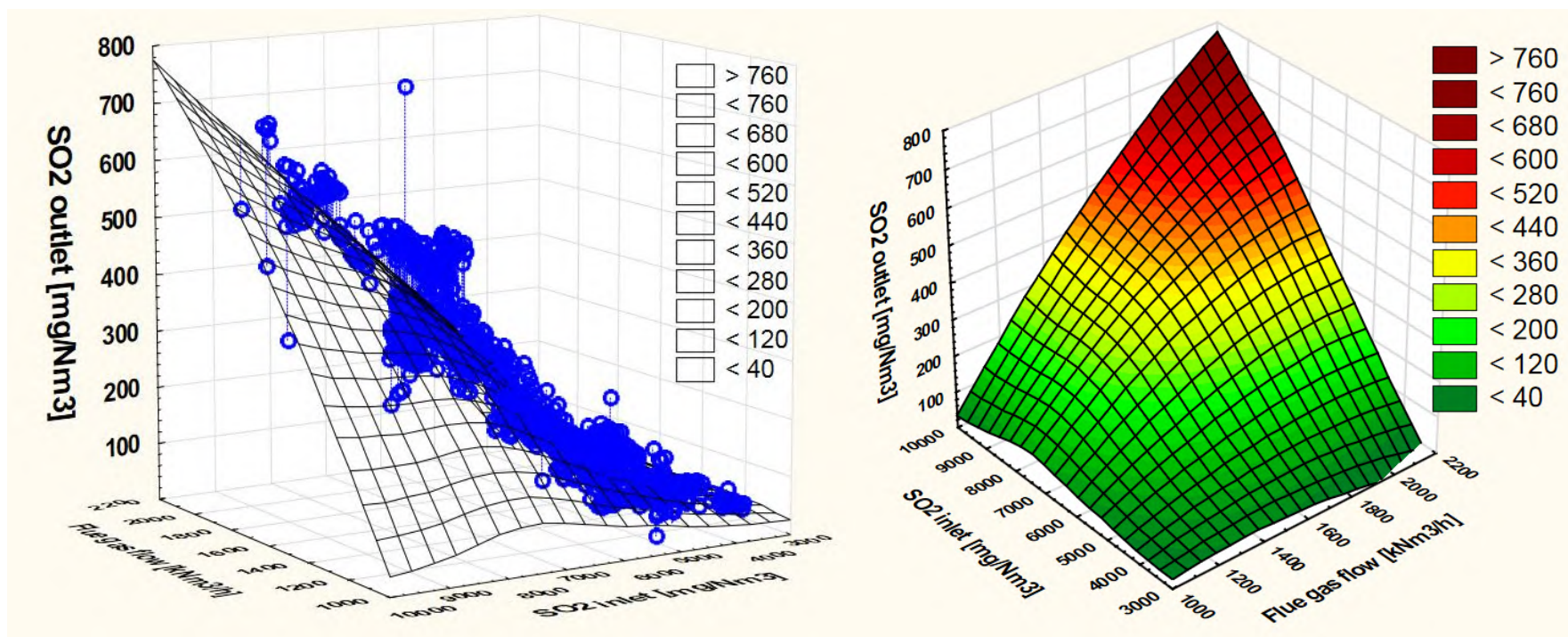
Developed on the basis of data from field equipment (continuous measurements of gas parameters)

3D diagram of SO₂ concentration in the clean gas at the chimney relative to the raw flue gas volume flow and SO₂ concentration at the FGD inlet for **3 spray banks in operation**.

~2000 measuring points

...

Curve fitting



Developed on the basis of the analysis of data from 1 full month of work **before** and **after** modernization (sampling period: 60s).

Visualization of the effects of absorber modernization on the example of unit 7.

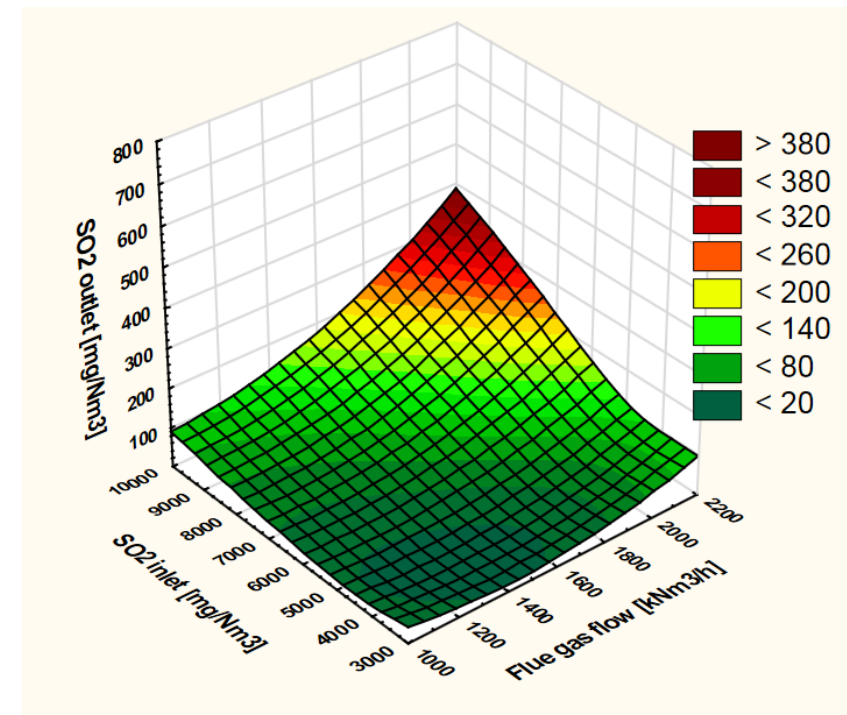
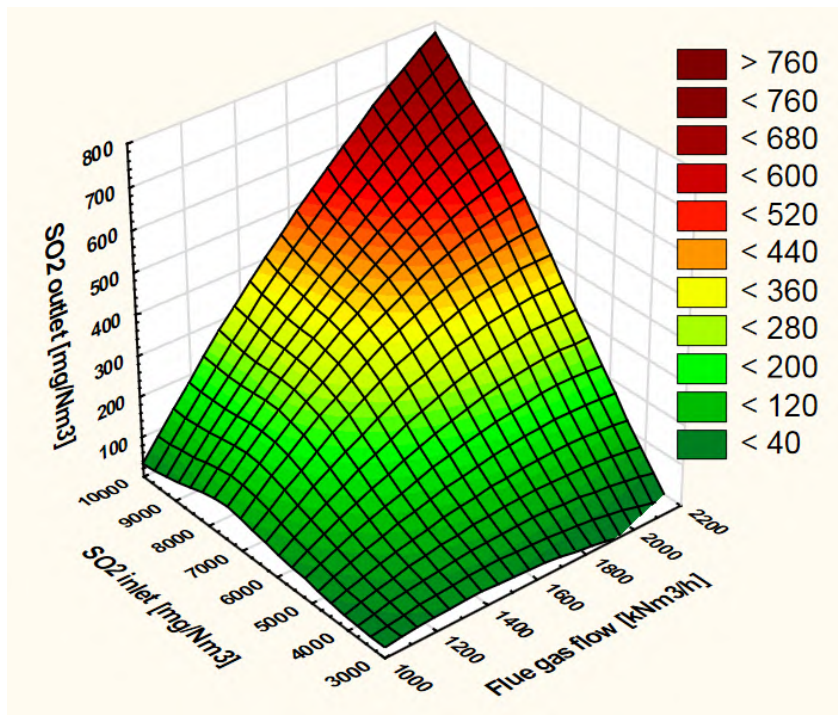
Synergistic effect of using new nozzles and FGD_2.0 process technology.

Developed on the basis of data from field equipment (continuous measurements of gas parameters)

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3D diagram of SO₂ concentration in the clean gas at the chimney relative to the raw flue gas volume flow and SO₂ concentration at the FGD inlet for 3 spray banks in operation.



Developed on the basis of the analysis of data from 1 full month of work **before** and **after** modernization (sampling period: 60s).

Comparison of the results of work from the monthly period before and after modernization allows us to conclude that the outlet concentration of SO₂, and thus SO₂ emissions, has been reduced by over 50%.

Results of warranty measurements made by an independent institute

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Unit	Date of warranty measurements	SO ₂ inlet [mg/Nm ³]	SO ₂ outlet [mg/Nm ³]	SO ₂ removal efficiency [%]
7	21.04 - 23.04.2020	9396	68	99,3
9	17.05 - 21.05.2021	7188	50	99,3
10	17.05 - 21.05.2021	7485	79	98,9
6	27.09 - 01.10.2021	8017	49	99,4
12	05.12 - 09.12.2021	9928	82	99,2
11	05.12 - 09.12.2021	9028	81	99,1
3	08.06 - 09.06.2022	9152	11 *)	99,9
4	08.06 - 09.06.2022	9458	120	98,7
5	10.08 - 11.08.2022	8328	84	99,0
8	05.10 - 06.10.2022	9324	107	98,9
on average		8730	73	99,2

The measurements were made at full power of the unit and all spray levels in operation (stable operation minimum 4 hours).
Measurement based on measuring grids (multi-point measurement).

*) Result for high pH level and high organic acid concentration.

CONCLUSION:

- After modernization, the absorbers achieved the assumed ability to maintain the outlet concentration of SO₂ below 130 mg/Nm³ for SO₂ concentrations at the inlet up to 10000 mg/Nm³ as a function of the pH of the absorber suspension and the volume flow of the raw flue gas.



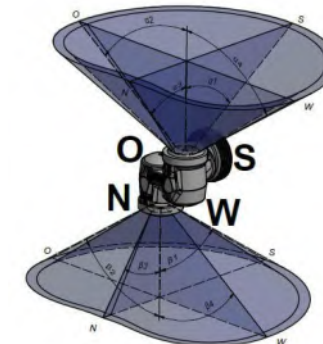
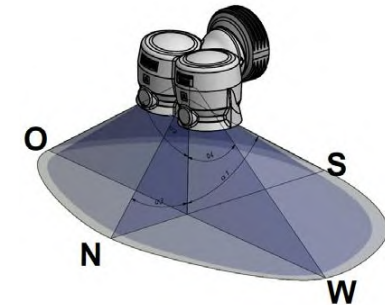
SKETCH	TECHNOLOGY	COMPANY
0,7 bar N: 35° O: 55° S: 55° W: 55° ± 5° 	TwinAbsorbPRO[®]	LECHLER GmbH For details please contact with: Thomas Schröder T: +49 (0) 7123 962- 315 M: +49 (0) 172 720 1993 E: Thomas.Schroeder@lechler.de
	FGD_2.0 process technology	RAFAKO S.A. For details please contact with: Jerzy Mazurek T: +48 32 410 1394 M: +48 602 760 006 E: Jerzy.Mazurek@rafako.com.pl

RETROFIT TPP MARITSA EAST III

CO-AUDITOR

STEINMÜLLER ENGINEERING GMBH

Dr.-Ing. Stefan Binkowski



Upgrade of 2 SO₂ scrubbers in Maritsa East 3 power station

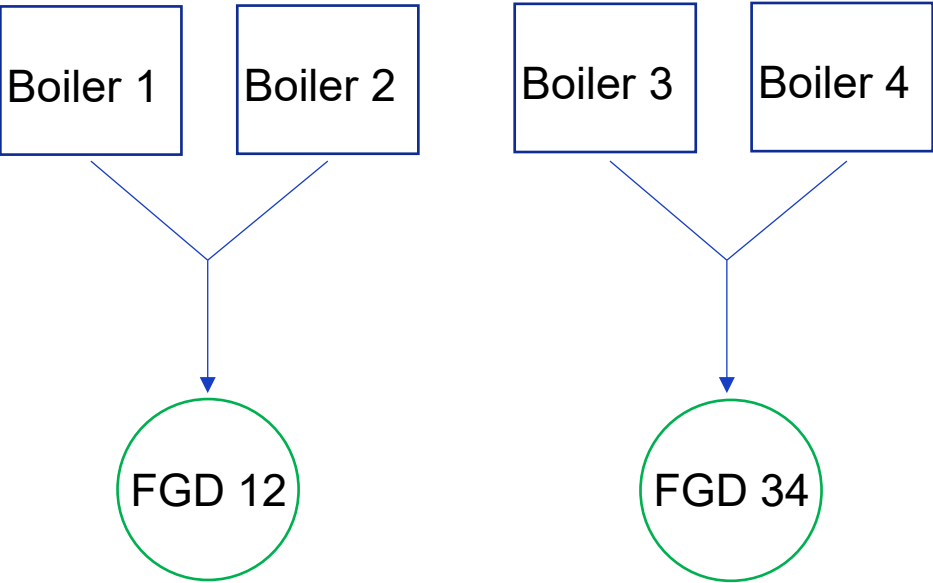
Rely on good experience with

steinmüller engineering

The Engineers Company

Description of Power Plant

- Maritsa East 3 Power Plant (operated by Contour Global in Bulgaria)
- 908 MWe (total) lignite-fired power plant with 4 x 227 MWe units
- Two wet-limestone FGDs

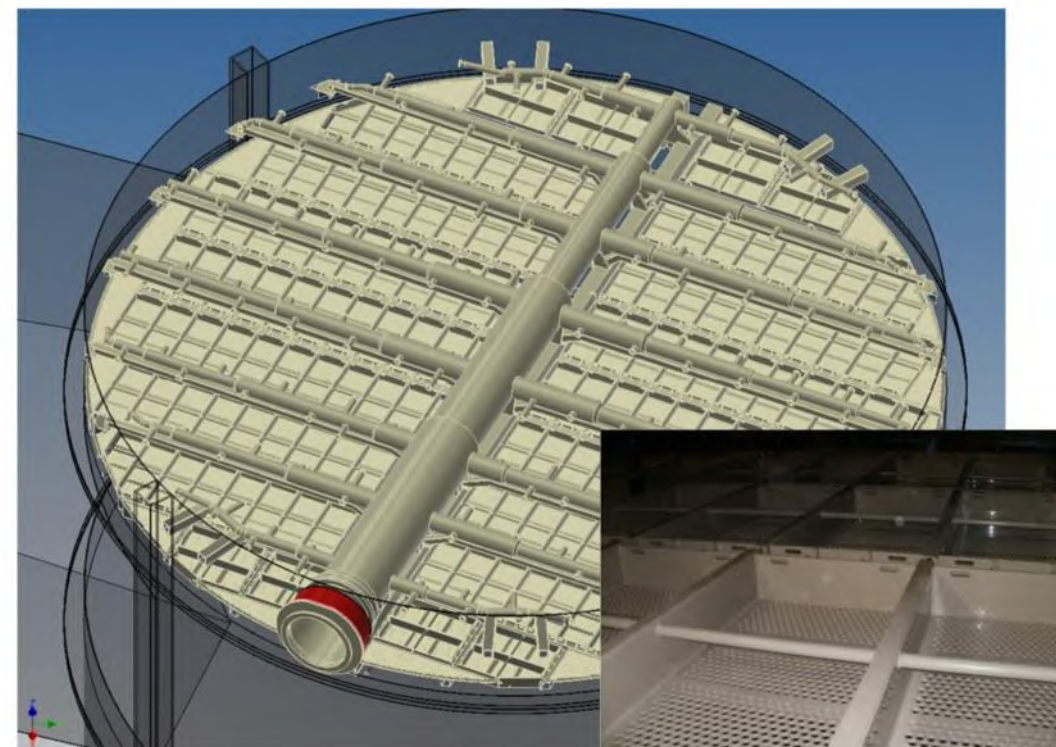
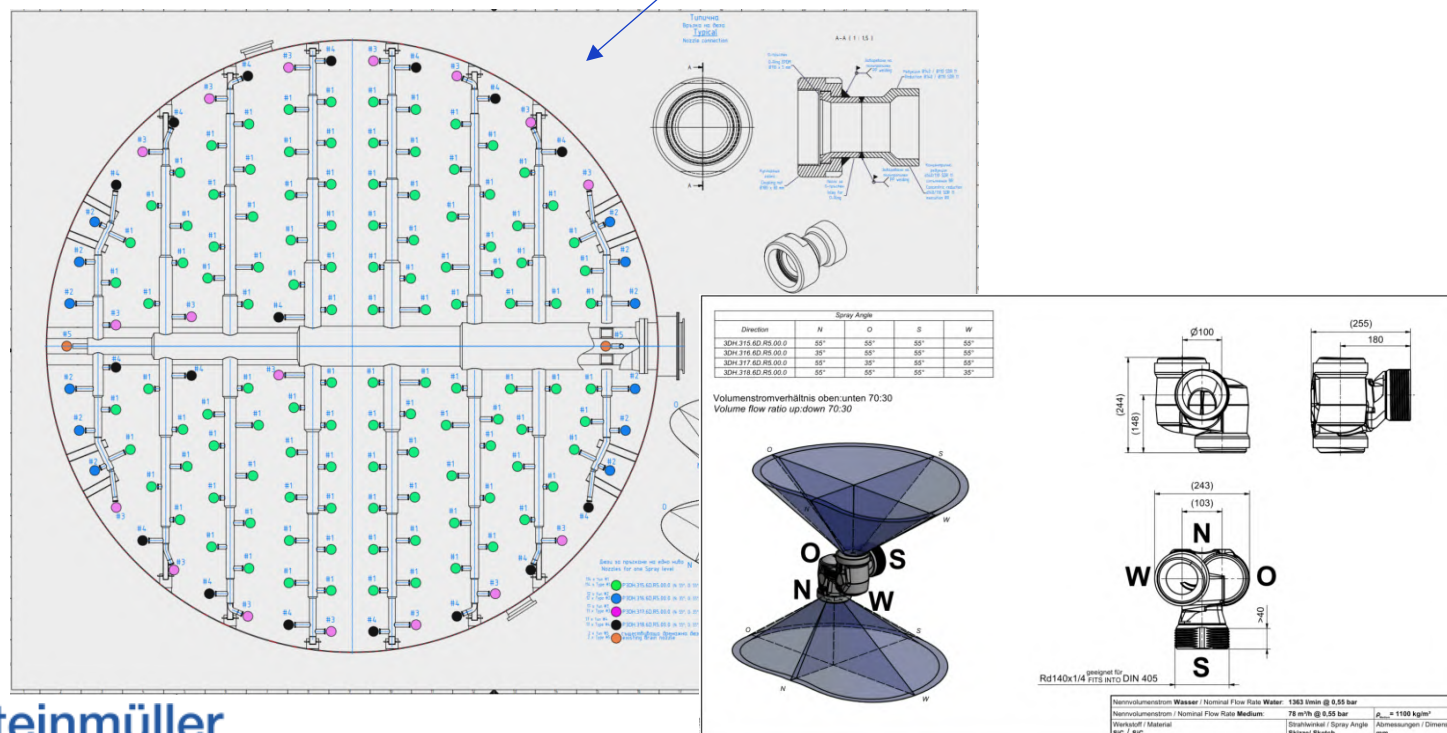
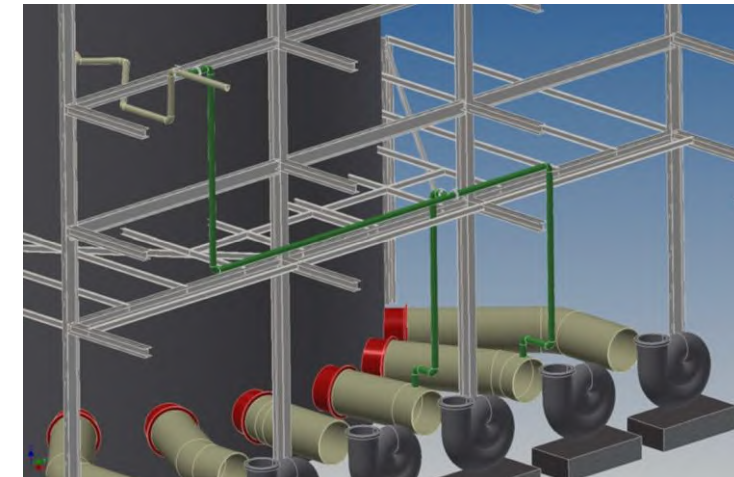


Characteristic	Unit	Value
Flue gas flow rate (wet)	m³/h (Normalized, wet, act O2)	3 223 451.19
Flow rate (dry)	m³/h (Normalized, dry, act O2)	2 542 107.24
SO ₂	mg/m³ (Normalized, dry)	15 415.57
SO ₂ @ 6% O ₂	mg/m³ (Normalized, dry)	18 500
Dust @ 6% O ₂	mg/mg (Normalized, dry)	50
N ₂ + Ar content	Vol. %, dry	79.9
O ₂ content	Vol. %, dry	8.5
CO ₂ content	Vol. %, dry	11.0
H ₂ O content	Vol. %, wet	21.1
Temperature	°C	179
Density	kg/m³ (Normalized, wet)	1.236
Suspension flow each spray bank	m³/h	12.000
Spray banks per absorber	-	6 (spraybank 1-5 with 50:50 up:down nozzles)
Limestone suspension feeding	-	Directly into absorber



Optimisation measures

- Increase of SO₂ removal efficiency by > 2 % (to min 97 %)
- Combination of 3 upgrades:
 1. Limestone dosing directly into recirculation lines
 2. Implementation of a tray level below the first spray bank
 3. Replacement of spray nozzles at spray level 1-5



Results:

- Improvements by tray installation:

- Homogenization of the flue gas flow through the complete absorber
 - Increase of SO₂ removal efficiency
 - Better utilization of limestone
- due to maximized reaction surface

- Improvements by feeding limestone suspension into recirculation lines:

- Direct contact of the absorbents with the flue gas → better utilization of the absorbent

- Improvements by changing the spray nozzles:

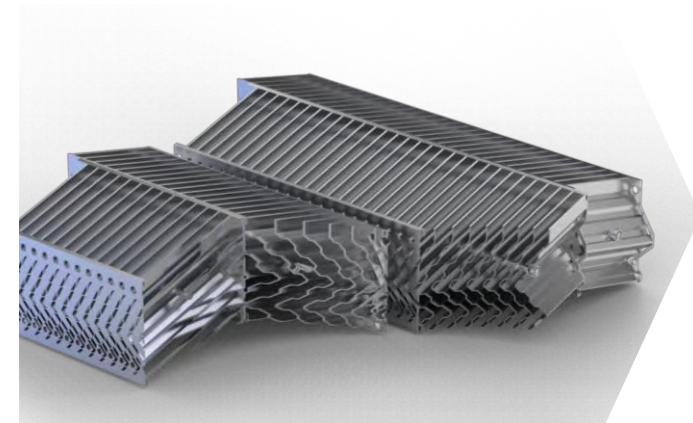
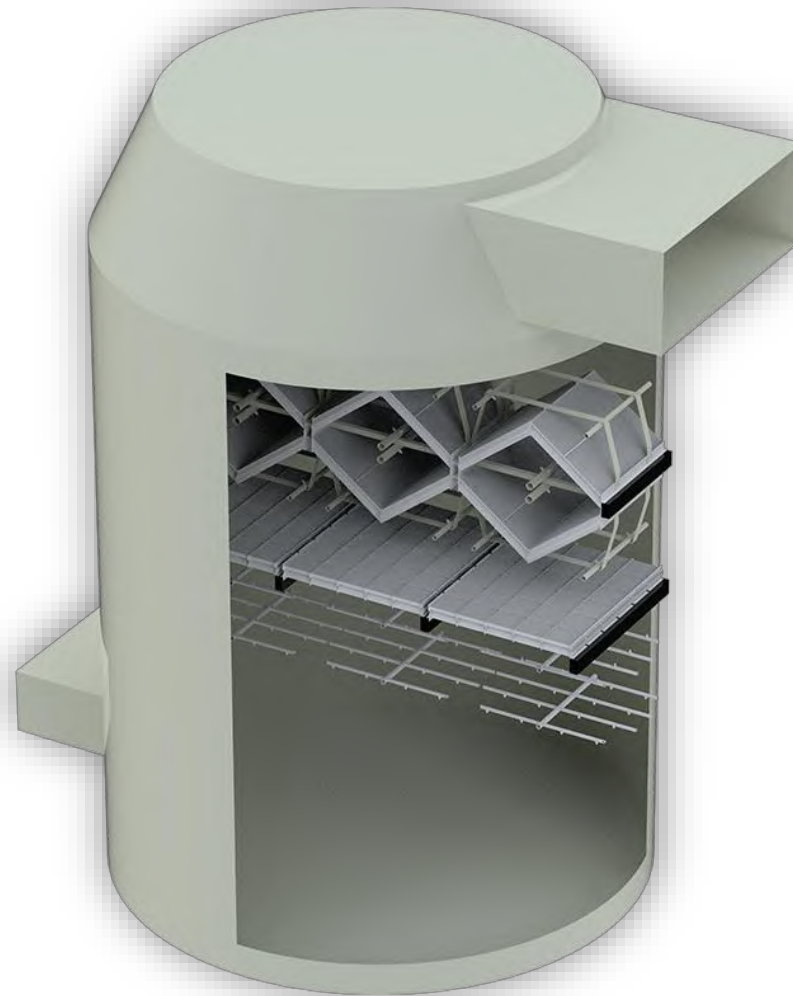
- 70:30 ratio (up:down) increases the amount of upwards sprayed droplets and thus the reaction time with the flue gas → improvement of SO₂ efficiency
- Decrease of pressure drop of the complete system due to higher portion of upwards directed droplets
- Less abrasion of absorber wall and support beams due to asymmetric spray cones

IMPORTANT TEAM MEMBER

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LECHLER DROPLET SEPARATOR SYSTEMS



CLOSING WORDS

"STRENGTH LIES IN DIFFERENCES, NOT IN SIMILARITIES" STEPHEN R. COVEY



OR SOME LIKE TO SAY „**SAME, SAME, BUT DIFFERENT**“



THANK YOU VERY MUCH FOR YOUR ATTENTION!



Lechler droplet on duty

FOR MORE INFORMATION, PLEASE CONTACT US
WE WILL BE GLAD TO ASSIST YOU

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