Air Pollution Control Systems for Power Stations and Waste to Energy plants

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Clean Megawatts Seminar
Content

1. introduction

2. State of the art for APC-system for WtE- and Power Plants

3. SO$_3$-Removal

4. Fabric filter as a key component in APC-Systems, examples
Performance of ete.a

- basic and detail engineering
- project management
- project steering
- concept development / optimizations
- studies
Business units of ete.a

- energy engineering
- environmental technology
- project management
References

Market share on WtE plants in Germany more than 25%

Power Plants:
- Vattenfall
- e.on
Dry Absorption

SNCR → Boiler → NaHCO₃ + HOK → Bag Filter → R → HEX → landfill

Conditioned Dry Absorption

SNCR → Boiler → H₂O → Ca(OH)₂ + HOK → Bag Filter → R → recirculation → landfill

Spray Absorption

SNCR → Boiler → Lime slurry + H₂O → Ca(OH)₂ + HOK → Bag Filter → SA → recirculation → landfill

Wet Scrubber

SNCR → Boiler → HOK → Bag-Filter → HEX → S1/S2 → S1/S2 → Lime slurry → Waste water → landfill

Q = quench
R = reactor
SA = spray absorber
S1/S2 = scrubber
HEX = heat exchanger

Source: fisia-babcock
Operation range of single stage dry absorption systems

HCl ≤ 2500 mg/m³
SO₂ ≤ 2000 mg/m³
NOₓ ≤ 100 mg/m³ (emission figures)
Experience with conditioned dry absorption systems

EBS-plant Romonta

Quelle: ALSTOM Power
Experience with conditioned dry absorption systems

Wte-plant Ludwigshafen

Quelle: Lühr-Filter
Operation range of multistage flue gas systems

If the HCl-raw gas concentrations as a permanent load is > 2500 mg/m³, a multistage system is necessary ....

HCl ≥ 2500 mg/m³
SO₂ ≥ 2000 mg/m³
NOₓ ≤ 50 mg/m³
(emission figures)
Operation range of multistage flue gas systems

HCl ≥ 2500 mg/m³
SO₂ ≥ 2000 mg/m³
NOₓ ≤ 100 mg/m³  (emission figure)
Single loop FGD with leakage free reheating

Source: fisia-babcock
New Generation of Power Stations - CO\textsubscript{2}\textsuperscript{-}Absorption

Anordnungsplan für eine Großanlage mit 800 MWel

Source: Hitachi Power Europe GmbH
New Generation of APC-Systems for Power Stations

Oxyfuel ($O_2/CO_2$ recycle) combustion capture
R&D project to investigate SO$_3$-removal
Aim / Motivation of the project

- Quantify the principle removal of SO$_3$, with limestone on a fabric filter

- Estimate the SO$_3$-removal efficiency of fly ash

- Quantify the influence of the mass balance limestone to flyash (distribution of sorbens)

Oxyfuel combustion

Cyclon

Fabric filter
SO$_3$-removal with limestone on a fabric filter

- SO$_3$-inlet average value 47,0 mg/m$^3$
- SO$_3$-outlet average value 0,5 mg/m$^3$
- average efficiency 98,9 %
Influence of the SO₃-efficiency at the gaseous phase on fly ash

- Nach Zyklon [SO₃mg/m³N]
- Vor Gewebefilter [SO₃mg/m³N]
- Abscheidegrad [%]

<table>
<thead>
<tr>
<th>Probe</th>
<th>Nach Zyklon</th>
<th>Vor Gewebefilter</th>
<th>Abscheidegrad [%]</th>
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<tbody>
<tr>
<td>P37</td>
<td>8.6 g/h</td>
<td></td>
<td></td>
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<tr>
<td>P38</td>
<td>21.6 g/h</td>
<td></td>
<td></td>
</tr>
<tr>
<td>P30</td>
<td>34.5 g/h</td>
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<tr>
<td>P31</td>
<td>34.5 g/h</td>
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<tr>
<td>P32</td>
<td>34.5 g/h</td>
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<td>P33</td>
<td>34.5 g/h</td>
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<td>P34</td>
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<td>P35</td>
<td>34.5 g/h</td>
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<tr>
<td>P41</td>
<td>34.5 g/h</td>
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<tr>
<td>P42</td>
<td>34.5 g/h</td>
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</tbody>
</table>
SO$_3$-removal efficiency depend on the calcium-equivalent

![Graph showing the relationship between SO$_3$-removal efficiency and calcium-equivalent concentration. The graph includes data points representing the average, maximum, and minimum absorption rates, with a trend line indicating the general trend.]
Design of a typical fabric filter, e.g. Typ ALSTOM, Optipuls LKP

- Synthetic Fiber Bags Up To 8 Meters Long.
- Sloped Partition Wall Between The Inlet and Outlet Plenum
- Shut-Off Dampers In The Inlet And Outlet Of the Filter Compartments Which Are Closed During Service.
- Dust Hopper
- Conveyor
- Wall, Dividing The Filter Into Compartments.
- Inspection Cover Above Bag Section. Easily Removed By Special Service Trolley.
- The Inlet Gas Distribution Baffle Provides Even Pressure On The Bags.
- The Service Area Can Be Provided With Full Weather Protection - Including Walls And Roof.
- Clean Gas Outlet

Characteristics of Fabric Filter/ Dry Absorption

Cleaning with a venturi
Secondary air
6 – 7 times more than primary air
- slowly puls
- short bag length (~ 3 m)

Direct Cleaning
Primary air expanded direct in the filter bag – Secondary air only app. 1-2 times of the Primary air
- short and rapid puls
- „deep“ puls for long filter bags (up to 8 m)
Characteristics of Fabric Filter/ Dry Absorption
Characteristics of Fabric Filter/ Dry Absorption

The main criteria for the design of a fabric filter are:

- **Air to Close Ratio**
  \[ v_F = \frac{\dot{V}_{i,B} [m^3/h]}{A_F [m^2]} = \text{Filterflächenbelastung} [m^3/m^2 h] \]

- **Pressure drop of the fabric filter**
  - for pure dust removal app. 8 – 12 mbar
  - for the combination dust removal and sorption app. 12 – 20 mbar. The maximum design pressure are mostly 25 – 35 mbar
Characteristics of Fabric Filter/ Dry Absorption

The main criteria for the design of a fabric filter are:

• Filter media
  - Resistance (temperature, chemical, mechanical)
  - condition of filtration (dust behaviour, removal efficiency, …)
  - costs
Surface oriented filtration

- Dust laden raw gas
- High porous dust cake
- Dense filtration sided fibre batt
- Clean gas sided fibre batt
- Clean gas

Quelle: Fa. Gutsche, Fulda
Optivel PI filter media construction (PPS basis)

- Surface oriented filtration due to P84 in the fibre blend
- No dust penetration into the cross-section of the needlefelt
- Longer bag life, constant low pressure drop, energy saving

Quelle: Fa. Gutsche, Fulda
Characteristics of Fabric Filter/ Dry Absorption

The main criteria for the design of a fabric filter are:

- Filtermedia

- consumption of pressurised air for filter cleaning

- flue gas distribution of the filter bags

- costs
### Examples

Liddell 4X500 MWe Coal Fired Power Station, Australia

ESP -> FF Conversion Retrofit

<table>
<thead>
<tr>
<th>Description</th>
<th>Value</th>
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<tbody>
<tr>
<td>Unit Rating (MWe)</td>
<td>500</td>
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<tr>
<td>Boiler Type</td>
<td>Pulverized coal fired</td>
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<tr>
<td>Gas volume (m³/h)</td>
<td>3,384,000</td>
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<tr>
<td>Gas temperature (degC)</td>
<td>135</td>
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<tr>
<td>Start-up</td>
<td>1991</td>
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<tr>
<td>No. of Bags (pcs.)</td>
<td>14,664</td>
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<tr>
<td>Bag length (m)</td>
<td>8</td>
</tr>
<tr>
<td>Bag material</td>
<td>PPS/PPS (Ryton)</td>
</tr>
<tr>
<td>Inlet fly ash (g/Nm³wg)</td>
<td>40</td>
</tr>
<tr>
<td>A/C-ratio (m/h)</td>
<td>72</td>
</tr>
<tr>
<td>Guarantee value (mg/Nm³dg)</td>
<td>80</td>
</tr>
<tr>
<td>Guarantee DP across bags (kPa)</td>
<td>1.35</td>
</tr>
</tbody>
</table>

Quelle: ALSTOM, ECS P. Wieslander
examples

Liddell 4X500 MWe Coal Fired Power Station, Australia

ESP -> FF Conversion Retrofit

Quelle: ALSTOM, ECS P. Wieslander
examples

Liddell 4X500 MWe Coal Fired Power Station, Australia

ESP -> FF Conversion
Retrofit

Quelle: ALSTOM, ECS P. Wieslander
examples Kogan Creek 750 MWe Coal Fired Power Station, Australia

- 750 MWe supercritical pulverized coal fired boiler in Queensland, Australia. Largest single generating unit in Australia.
- Boiler delivered by Babcock Hitachi in Japan
- Base load boiler
- Coal ash content approx. 25 - 28 %, coal S-content approx. 0.3 – 0.5 %
- Start-up fuel: Low S diesel oil (max 0.3 % S)
- Boiler commissioned May 2007

Quelle: ALSTOM, ECS P. Wieslander
examples

Kogan Creek 750 MWe Coal Fired Power Station, Australia

Quelle: ALSTOM, ECS P. Wieslander
examples

Kogan Creek 750 MWe Coal Fired Power Station, Australia

Quelle: ALSTOM, ECS P. Wieslander
examples

Kogan Creek 750 MWe Coal Fired Power Station, Australia

- Plant layout: Boiler -> APH -> FF -> Fan -> Stack
- Design gas flow $958 \text{ m}^3/\text{s} @ 125 \text{ degC}$
- Inlet fly ash $39 \text{ g/Nm}^3_{\text{wg}}$ (performance coal), $48 \text{ g/Nm}^3_{\text{wg}}$ (worst coal)
- FF size 2 x LKP-2x4x1020-8.0, filter area $52,224 \text{ m}^2$
- FF design A/C-ratio 66 m/h N, 70.4 m/h N-1
- FF flange-to-flange pressure drop guarantee: $2 \text{ kPa (N-1)}$
- FF dust emission guarantee: $50 \text{ mg/Nm}^3_{\text{dg}}$
- FF dust emission measured at $6 \text{ mg/Nm}^3_{\text{dg}}$ at actual gas flow $1053 \text{ m}^3/\text{s}$, vs design $958 \text{ m}^3/\text{s}$ (+ 10 %)
- Bag material: PPS/PPS (Ryton/Ryton)
- Laboratory bag analysis performed August 2008 at approximately 9000 operating hours shows that the bags are in very good condition.

Quelle: ALSTOM, ECS P. Wieslander
examples

Kogan Creek 750 MWe Coal Fired Power Station, Australia

Quelle: ALSTOM, ECS P. Wieslander
examples

Kogan Creek 750 MWe Coal Fired Power Station, Australia

Quelle: ALSTOM, ECS P. Wieslander
Thank you for your attention!