ECOPURE® CCF
CATALYTIC CANDLE FILTRATION

Gary Elliott, Ceramic filter Specialist, CTS

January 2019

www.durr.com
GLOBAL POSITIONING OF CLEAN TECHNOLOGY SYSTEMS

November 2017: Approx. 538 employees at 8 locations in 7 countries

- Dürr Systems AG, Bietigheim-Bissingen
  - Employees: 144
- Dürr Systems Inc., Southfield, USA
  - Employees: 76
- Dürr Korea Inc., Seoul, Southkorea
  - Employees: 54
- Dürr India Private Ltd., Chennai, India
  - Employees: 13
- Dürr Thailand Ltd., Bangkok, Thailand
  - Employees: 4
- Luft- und Thermotechnik Bayreuth GmbH, Goldkronach
  - Employees: 95
- Olpidürr S.p.A., Milano
  - Employees: 6
- Dürr Paintshop Systems Engineering, (Shanghai) Corp. Ltd., China
  - Employees: 146
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Schematic diagram

Urea / Ammonia Injection for NOx Control

Dry Sorbent Injection for SOx/HCl Control

FURNACE OFF GAS

CLEAN GAS
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CCF in glass industry

WASTE HEAT RECOVERY (OPTIONAL)
» e.g. heating of production area

GLAS-KILN

SORBENT AND REDUCTANT INJECTION

CATALYTIC FILTER SYSTEM

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Catalytic Candle Filters: Properties

» Combined removal of dusts, nitrogen oxides and gaseous acid precursors
» High temperature application
  » > 250 – 450°C (900°C)
  » Thermal shock resistant

» Low density 400 kg/m³
  » Light weight (ca. 12 kg)
  » 70 – 95 % porosity
  » Chemically resistant fibers
  » High removal efficiency of dust
  » Low pressure drop
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DeDust: Dust Removal

- Surface filtration on conditioned layer (Filter Cake)
- Dust removal by reversed pulse air (Pulse-Jet-System)
- Filter element does not expand (rigid filter material)
- Keeps a residual filter cake layer
- Negligible dust penetration into the filter body
- High filtration efficiency – HEPA*
- Operates with variable dust loads

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DeSOx: Mechanisms of Desulfurization

- Alkaline additives neutralize gaseous acid precursors (HCl, HF, SOx) into powdered products

- Desulphurization reactions
  - $\text{Ca(OH)}_2 + \text{SO}_3 \rightarrow \text{CaSO}_4 + \text{H}_2\text{O}$
  - $\text{Ca(OH)}_2 + \text{SO}_2 \rightarrow \text{CaSO}_3 + \text{H}_2\text{O}$
  - $\text{Ca(OH)}_2 + \text{SO}_2 \frac{1}{2}\text{O}_2 \rightarrow \text{CaSO}_4 + \text{H}_2\text{O}$
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DeNOx: Mechanisms of Denitrification

- Ammonia and urea reduce nitrogen oxides (NO, NO2) to nitrogen N2 and water H2O
- Denitrification reactions
  - $4\text{NO} + 4\text{NH}_3 + \text{O}_2 \rightarrow 4\text{N}_2 + 6\text{H}_2\text{O}$
  - $\text{NO} + \text{NO}_2 + 2\text{NH}_3 \rightarrow 2\text{N}_2 + 3\text{H}_2\text{O}$
  - $6\text{NO}_2 + 8\text{NH}_3 \rightarrow 7\text{N}_2 + 12\text{H}_2\text{O}$

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**DeNOx: Denitrification**

- Catalyst finely dispersed throughout the wall of the filter
- Large surface area
- No gas film (i.e. diffusion) limitation
- Catalyst is protected from masking and poisoning by dust constituents

![Diagram of ECOPURE® CCF](image)
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DeNOx: Mechanisms of Denitrification

- Optimum temperature window between 260 and 400°C
- Best efficiency for glass industry with NOx of up to 5000 mg/m³
- Efficiency will be stable for a long time (minimum decrease)
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Process Comparison: ESP vs. CCF vs. Fabric Filter

Fabric Filter:
- Low dust arrangement
  - Broken temperature link
  - Long catalyst lifetime

Ecopure® CCF
Catalytic filter arrangement
- Perfect temperature link
- Long catalyst lifetime

ESP:
Tail-end arrangement
- Perfect temperature link
- Limited catalyst lifetime
## ECOPURE® CCF

Process Comparison: ESP vs. CCF vs. Fabric Filter

<table>
<thead>
<tr>
<th>Type and criteria</th>
<th>ESP + SCR</th>
<th>Bag Filter + SCR</th>
<th>Ecopure® CCF</th>
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</thead>
<tbody>
<tr>
<td>Required space</td>
<td>★</td>
<td>★★</td>
<td>★★★</td>
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<tr>
<td>Dust emissions</td>
<td>★★</td>
<td>★★★</td>
<td>★★★</td>
</tr>
<tr>
<td>Reduction of PM10</td>
<td>★★</td>
<td>★★★</td>
<td>★★★</td>
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<tr>
<td>NOx emissions/ Ammonia slip</td>
<td>★★</td>
<td>★★</td>
<td>★★★</td>
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<tr>
<td>Maintenance</td>
<td>★★</td>
<td>★</td>
<td>★★★</td>
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<tr>
<td>Utility consumption</td>
<td>★★</td>
<td>★</td>
<td>★★★</td>
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<tr>
<td>Catalyst lifetime</td>
<td>★★</td>
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<td>★★★</td>
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<tr>
<td>Recovery of energy downstream</td>
<td>★★</td>
<td>★★</td>
<td>★★★</td>
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## ECOPURE® CCF

References Glass Industry

<table>
<thead>
<tr>
<th>Libbey Glassware (China) Co. Ltd.</th>
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<tbody>
<tr>
<td><strong>Location:</strong></td>
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<tr>
<td><strong>Application:</strong></td>
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<td><strong>Pollutants:</strong></td>
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<tr>
<td><strong>Flow rate:</strong></td>
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<td><strong>Solution:</strong></td>
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<td><strong>Installed:</strong></td>
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**Furnace particularities**

- Natural gas fired furnace
- Regenerative
- Waste heat management
- 1 burner per side
- Variations of NOx level between reversal sides
- Frequent capacity variations
- Manual burner management

**NOx profile during flow reversal and in reversal position**
Stepwise adaption to furnace particularities

- Fixed injection amount of urea for each reversal side
- Account for furnace reversal signal and historic NOx data
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References Glass Industry: Libbey – Project schedule

Project schedule
- Order award: Dec. 2015
- Start of civil work: Jan. 2016
- Installation started: Mar. 2016
- Final acceptance: Jul. 2016
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References Glass Industry: Libbey – Performance

Performance requirements

- NOx: > 80% < 200 ppm
- SO2: > 70% < 50 ppm
- Dust: > 80% < 0.01 gr/ft³

Performance achievements

- NOx: > 95% < 50 ppm
- SO2: > 90% < 18 ppm
- Dust: > 80% < 0.01 gr/ft³
- NH3: < 3.5 ppm

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Lauscha Fiber International GmbH

Location: Lauscha, Germany

Application: Glass fibre production, Glass furnace exhaust air

Pollutants: Dust, SO\textsubscript{x}, NO\textsubscript{x}

Flow rate: 15,000 Nm\textsuperscript{3}/h @ 400 °C

Solution: Ecopure\textsuperscript{®} CCF - Catalytic Candle Filter

Installed: 2017
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References Glass Industry
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<table>
<thead>
<tr>
<th>Wiegand-Glas GmbH</th>
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<td>Application:</td>
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References Glass Industry

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<tr>
<th>HEINZ-GLAS Dzialdowo Sp. z o.o.</th>
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<th>Kibing Photovoltaic Photoelectric Glass Co., Ltd.</th>
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<tr>
<td><strong>Location:</strong> Chenzhou, Hunan, CN</td>
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<tr>
<td><strong>Application:</strong> Flat glass production, Glass furnace exhaust air</td>
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<tr>
<td><strong>Pollutants:</strong> Dust, SO(_x), NO(_x), HCl, HF</td>
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<tr>
<td><strong>Flow rate:</strong> 144.000 Nm(^3)/h @ 350 °C</td>
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<tr>
<td><strong>Solution:</strong> Ecopure® CCF - Catalytic Candle Filter</td>
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<td><strong>Installed:</strong> under construction</td>
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Summary

» “3 in 1” air pollution control system
» Air pollution control functions
  » DeDust: Dust removal
  » DeSOx: Removal of gaseous acid precursors by sorbent injection
  » DeNOx: Removal of nitrogen oxides by reducing agent injection
» High cleaning efficiency
  » Dust < 2mg/Nm3
  » SOx ca. 80%
  » NOx ca. 90%
» High temperature applications (250 – 900°C) and thermal shock resistance
» Corrosion resistant fiber materials
» On line maintenance possible
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