A COMPACT GRANULAR BED FILTER FOR IGCC HOT GAS CLEAN-UP

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Presentation Outline

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  - Filtration Mode
  - “Puff-back” Mode
  - New Filter Design
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  - Setup
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Motivation

• To develop a reliable high temperature gas cleaning unit

**WHY high temperature?**

• Efficient conversion of fuel to energy in power plants
• Protection of downstream process equipments
• Environmental regulations
Objective

To build and test a new Panel Bed Filter design

Improvement aims reducing:
1. Number of gas-entry surfaces per unit module
2. Number of modules per unit filter
3. Filter footprint
4. Initial and residual pressure drop
Introduction - Working principle of PBF
Introduction – Filtration mode

Filtration mode involves the use of clean granular medium to filter dirty gas, resulting in clean gas.

- Dirty Gas enters through the filter cake roots.
- Clean gas is produced from the clean granular medium.
- The process helps in the separation and purification of gases.
Introduction – Puff-back mode

- Filter cake
- Outermost layers
- Gas pulse
- Gap closing with new granular bed
- Filter cake roots remain intact
Introduction – New Filter vs. previous design
Introduction – Lab scale rig

Dirty gas compartment

Outlet cone

Feeding container

Outlet cone

Clean gas compartment

Collecting container

40 mm
Experiment – Operating Parameters

**Filtration medium:**
Sintered Bauxite
- Sphericity: 0.9
- Density: 2040 g/m$^3$
- Mean diameter: 0.662 & 0.458 mm

**Filtration dust:**
Arizona test dust, A1 & A2
- Loose bulk density: 650 g/m$^3$
- Mean diameter: 9 & 4 μm
# Experiment – Operating Parameters

<table>
<thead>
<tr>
<th>Operating Conditions</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>Temperature</td>
<td>20 °C, 120 °C</td>
</tr>
<tr>
<td>Volume flow</td>
<td>6-35 m³/h</td>
</tr>
<tr>
<td>Filtration velocity</td>
<td>2.50 to 14.94 cm/s</td>
</tr>
<tr>
<td>Inlet dust concentration</td>
<td>2–18 g/m³</td>
</tr>
<tr>
<td>Tank Pressure</td>
<td>7 bar absolute</td>
</tr>
<tr>
<td>Pulse duration</td>
<td>30 - 50 ms</td>
</tr>
<tr>
<td>Puff-back pressure drop</td>
<td>650, 1500, 2000, 2500 Pa</td>
</tr>
<tr>
<td>Spill during each puff-back</td>
<td>150–200 g</td>
</tr>
</tbody>
</table>
Experiment - Setup

Pressure tank

Time Reg

Dust

Powder disperser

Electrical Heater

Absolute filter

Heat exchanger

Critical nozzle

Vacuum pump

Rotameter

Filtered air

Pressure

Temperature

Pressure drop

Compressed air

Heated air

Dusty air

Puff-back

Filtered air

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Results – Clean-bed Pressure drop

- **New design-Filter tray**
- **Previous design-L10-56**

The graph shows the relationship between clean-bed pressure drop [Pa] and velocity [cm/s] for two different designs. The data points indicate that the new design has a lower pressure drop compared to the previous design across various velocities.
Results - short term

- Pressure drop
- Filtration velocity

- Pressure drop: 1500 Pa, 150 Pa, 170 Pa, 175 Pa
- Filtration velocity: 5 cm/s

Graph showing time vs. pressure drop and filtration velocity.
Results - short term

Δp [Pa]

Filtration velocity [cm/s]

1500 Pa

9.5 cm/s

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Results – Inadequate cleaning

![Graph showing Δp vs time for inadequate cleaning]
Results - long term - 9.4 cm/s, 2 g/m³

\[ \Delta p \text{ after cleaning} \quad \Delta p \text{ before cleaning} \quad \Delta p \text{ at start-up} \]

\[ 2000 \text{Pa} \]
Results – extreme conditions: 3 cm/s, 18 g/m³
Results – PSD - coarse particles

![Graph showing particle size distribution before and after an experiment. The graph displays cumulative volume as a percentage against particle size (µm) on a logarithmic scale. The x-axis represents particle size (µm) ranging from 0.1 to 100, while the y-axis represents cumulative volume (%) ranging from 0 to 100. Two curves are shown: one for after the experiment (blue) and one for before the experiment (magenta). Circle highlights a difference at approximately 4 µm and 7 µm.]

4 µm 7 µm
Conclusion

✓ ↓ number of louvers per unit module by ↑ gas-entry surface area per unit louver
✓ Constant residual pressure drop → sufficient pressure pulse transmitted during puff-back mode

Compared to previous panel bed filter designs:
✓ Lower initial and residual pressure drop
✓ Longer filtration cycles → reduced puff-back frequency
Future work

- Details studies with $d_{50} = 4 \, \mu m$
- SEM analysis of the filter cake structure
- Emission/Penetration test
- Higher temperature
THANK YOU FOR YOUR ATTENTION