EVALUATION OF CIRCULATING FLUIDIZED BED-DRY FLUE GAS DESULFURIZATION (CFB-FGD) BYPRODUCTS IN CEMENT APPLICATIONS

Robert (Bob) Jewell, Anne Oberlink, Thomas Robl, Kevin Henke, and Tristana Duvallet
University of Kentucky Center for Applied Energy Research

Muh-Cheng M. Wu, Qingfa Su
Lonjing Environment Technology Co. Ltd

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INTRODUCTION

• Formation of Sino-American SDA Association
  • Lonjing Environment Company Co. Ltd.
  • Xiamen, Fujian, China (http://www.longking.cn/Index.asp?language=en)

• Overarching Objective:
  • To combine complimentary resources of research and industrial organizations in the U.S. and China to overcome barriers for the commercial utilization of DRY FGD byproduct
INTRODUCTION

• Solutions for increasing volume of dry scrubber byproducts?

• Characterize and test the performance of dry FGD byproducts
  • Additive to portland cement mortar and concrete

1. Evaluate the “as-received” byproduct
2. Produce a 3 micron ultrafine-ash (UFA) component
BACKGROUND

• Wet System
  • Inject aqueous slurry of sorbent into flue gas
  • Byproduct: slurry

• Semi-Dry system (Spray Dryers; SDA)
  • Similar to wet system, but with higher sorbent concentration
  • Byproduct: dry

• Dry System (Circulating Dry Scrubbers; CDS)
  • Descendent of Lurgi CDS system (Germany, 1980’s)
    • An emergent technology; demonstrated in the U.S. at the AES Greenidge station
    • Better calcium utilization
    • May use higher sulfur coal
  • Pneumatically inject dry sorbent directly into fluidized-bed absorber for desulfurization
    • Byproduct: Dry
  • Flexible Technology
    • Fuel flexibility
    • Multi-pollutant control capability (SO₂, SO₃, HCL, HF, Hg)
BACKGROUND

Hydrated Lime

CFB absorber

Dedusting

Cleaned Fuel Gas

Recirculation

Product Silo

H₂O

Rue Gas

Product
MATERIALS

• Lonjing CFB-FGD Byproduct
  • FBC Boiler

• U.S. CFB-FGD Byproduct
  • PCC Boiler
## MATERIALS

<table>
<thead>
<tr>
<th>Sample</th>
<th>SiO₂</th>
<th>Al₂O₃</th>
<th>Fe₂O₃</th>
<th>CaO</th>
<th>MgO</th>
<th>Na₂O</th>
<th>K₂O</th>
<th>P₂O₅</th>
<th>TiO₂</th>
<th>SO₃</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lonjing CFB-FGD (LAR)</td>
<td>41.60</td>
<td>24.94</td>
<td>4.52</td>
<td>19.08</td>
<td>1.42</td>
<td>0.15</td>
<td>0.92</td>
<td>0.15</td>
<td>0.83</td>
<td>6.52</td>
</tr>
<tr>
<td>U.S. CFB-FGD (UAR)</td>
<td>29.15</td>
<td>15.43</td>
<td>6.86</td>
<td>23.95</td>
<td>0.82</td>
<td>0.05</td>
<td>1.17</td>
<td>0.09</td>
<td>0.61</td>
<td>21.45</td>
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</tbody>
</table>

Image from: Commonwealth Journal
MATERIALS

LONJING CFB-FGD

U.S. CFB-FGD

Q = SiO₂
An = CaSO₄
CH = Ca(OH)₂
C = CaCO₃
H = CaSO₃·½H₂O
M = Al₆Si₂O₁₂

Quartz        Anhydrite         Portlandite          Calcite            Hannebachite         Mullite 8
PRODUCTION OF ULTRAFINE ASH

ROTARY BALL MILL  ATTRITOR STIRRED BALL MILL
PRODUCTION OF ULTRA FINE ASH

**DRY MILLING**

**WET MILLING**

<table>
<thead>
<tr>
<th>Time (mins)</th>
<th>Particle Size (microns)</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>d10</td>
</tr>
<tr>
<td>0</td>
<td>3.88</td>
</tr>
<tr>
<td>120</td>
<td>2.19</td>
</tr>
<tr>
<td>240</td>
<td>1.6</td>
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<td>0</td>
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<tr>
<td>30</td>
<td>1.35</td>
</tr>
<tr>
<td>60</td>
<td>1.31</td>
</tr>
<tr>
<td>90</td>
<td>1.07</td>
</tr>
</tbody>
</table>
SEM ANALYSIS

AS-RECEIVED

ULTRA FINE ASH

300x magnification

1000x magnification
CHARACTERISTICS OF UFA

DRY MILLED

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<td>Dry Milled</td>
<td>41.60</td>
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<td>1.42</td>
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<td>0.92</td>
<td>0.15</td>
<td>0.83</td>
<td>6.52</td>
</tr>
<tr>
<td>Wet Milled (LUFA)</td>
<td>41.70</td>
<td>24.44</td>
<td>6.02</td>
<td>18.66</td>
<td>1.38</td>
<td>0.14</td>
<td>0.90</td>
<td>0.15</td>
<td>0.83</td>
<td>6.26</td>
</tr>
</tbody>
</table>

WET MILLED
STRENGTH TESTING - MORTAR

- ASTM testing methods (C 109)
  - 5.08 cm cubes
  - 20% replacement of cement

25% increase

\[
d_{50} = 3 \, \mu m \\
d_{50} = 9 \, \mu m \\
d_{50} = 14 \, \mu m \\
d_{50} = 23 \, \mu m \\
d_{50} = 3 \, \mu m
\]
DIMENSIONAL STABILITY - EXPANSION

- ASTM C 157
- 20% replacement of cement
DIMENSIONAL STABILITY - SHRINKAGE

- ASTM C 596
- 20% replacement of cement

Control - OPC
UAR
LAR
LUFA
PERFORMANCE UFA IN CONCRETE

- ASTM C 192 and C 39
- 7.62 cm x 15.24 cm cylindrical specimens
- 20% replacement of cement
- water:cement ratio = 0.49
  - Based on a 41 MPa at 28 days compressive strength
UFA IN CONCRETE

Compressive Strength (MPa) vs Curing Time (days)

- Control - OPC
- UAR
- LAR
- LUFA

Compressive Strength 20% increase after 50 days of curing.
SUMMARY

• CFB-FGD byproduct may be used as a partial replacement of ordinary portland cement
• CFB-FGD byproduct has a retarding effect on strength at 1 day of curing
• With increased strength after 7 days
• CFB-FGD ultrafine ash with a d50 of 3 microns does increase the strength performance of a cementitious composite
• Additional long-term evaluation should be carried out
THANK YOU!
bob.jewell@uky.edu