Coal Creek Prototype Fluidized Bed Coal Dryer:

Performance Improvement, Emissions Reduction, and Operating Experience

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Introduction

- Coal moisture has a large negative effect on boiler efficiency, station service power and unit heat rate.
- For a 600 MW lignite-fired unit, fuel moisture is responsible for:
  - 9% higher coal flow rate
  - 20 MW of station service power
  - 20% higher flue gas flow rate
  - Increased operating and maintenance cost
- Can a low-temperature waste heat be used to reduce fuel moisture?
**Project Goals and Schedule**

**Goals and Objectives:**
- Reduce moisture content of lignite, PRB, and other high-moisture coals.
- Use waste heat from the power plant.
- Modify existing coal handling systems.
- Increase competitive position of lignite-, PRB-, and other high-moisture coal-fired power plants.
- Reduce environmental impact of lignite-, PRB-, and other high-moisture coal-fired power plants.

**Project Phases and Schedule:**

- **Coal Pile Testing, Initial Fluidized Bed Dryer Design 2002**
- **Pilot Dryer 2 T/hr 2003-2004**
- **Phase 1 Prototype Dryer 112T/hr 2005-2007**
- **Phase 2 Commercial Application 2008-**
Lignite Fuel Enhancement: Incremental Moisture Reduction Project

- Less Moisture:
  - Lower Exit Gas Temperature
  - Lower Exit Gas Volume
  - Lower Exit Gas Velocity
  - Less Power for Mills
  - Less Power for FD & ID Fans
  - Less Duct Erosion & Maint.

- Less Ash
- Less SO₂
- Less CO₂
- Less Mercury

- Increased Efficiency
- More MW/Ton

- Increased Efficiency
- Less Flue Gas
- Lower Velocity

- Increased Efficiency
- Less Flue Gas
- Lower Velocity
- Less Evaporation
**Previous Work**

1997-1998
- Preliminary studies and concept development

1999
- Lignite-drying tests at Coal Creek using low-temperature fixed-bed dryer.

2000
- Coal Creek boiler modeling
- Laboratory lignite drying tests.
- Full-scale test burns (20,000 tons of lignite dried using low-temperature air, and burned at Coal Creek).

2001
- Fluidized bed selected for coal drying
- Laboratory drying tests at Lehigh University

2002
- Application filed with DOE under the Clean Coal Power Initiative (CCPI).
Previous Work

2003
- Project selected for negotiation with DOE.
- 2 ton/hr pilot fluidized bed dryer built at Coal Creek with NDIC funding.
- Pilot coal dryer testing at Coal Creek

2004
- Contract signed with DOE (Clean Coal Power Initiative).
- DOE joined partnership under collaborative agreement.
- Design of a prototype coal dryer and associate equipment.

2005
- Construction begins of a prototype coal dryer at Coal Creek Unit 2.

2006
- Prototype coal dryer checkout and start-up
- Prototype coal dryer performance testing (in progress)
- Unit performance testing (in progress)
- August: Phase 1 Milestone
Pilot Coal Dryer at Coal Creek

- Pilot fluidized bed dryer was designed and operated to determine drying rates of North Dakota lignite.
- Low-temperature lignite drying process.
- No appreciable carbon oxidation, and devolatilization.
- No operational difficulties.
- Results showed it is possible to remove substantial fraction of S and Hg from the coal.
Description of Host Unit

Coal Creek Station:
- 1,200 MW lignite-fired
- Two T-fired CE boilers
- 2,400 psig @ 1,000 °F /1,000 °F
- Two single reheat GE G-2 turbines
- 3 Cooling towers
- Fuel HHV = 6,200 BTU/lb
- Fuel moisture = 38 percent
- Coal fired = 900,000 lb/hr per unit
Coal Creek Station
Prototype Coal Drying System at Coal Creek
Prototype Coal Dryer

- Maximum capacity 112.5 t/hr.
- Remove approx. ¼ of coal moisture.
  - Dry lignite from 38% to 29.5%.
  - Improve HHV from 6,200 to 7,045 BTU/lb
- Fully automated operation, integrated into the plant control system.

Four patent applications on dryer design and control filed by GRE.
Prototype Dryer: Unit 2 East
Prototype Dryer Installation
Prototype CDS: Vibrating Coal Feeder
Prototype CDS: Feed Conveyor to Dryer
Prototype CDS: Fluidized Bed Coal Dryer
Prototype CDS Checkout, Start-Up, and Operation Summary

- Checkout and “shakedown” in December 2005.
  - No problems
- 1st coal on January 30th 2006.
- 7-hour daily tests
- Inspection on Feb 11th,
  - No accumulation of material in the dryer
- Drying to 29.5%
- Operator training before 24/7 operation
- Performance testing in March and April 2006.
Prototype Coal Dryer (CD26) Performance
Prototype Coal Dryer Performance: March to April, 2006

Total Coal Moisture Content [%]

Test Date

Wet Feed
Dried Product
Prototype Coal Dryer Performance: March to April, 2006

Coal HHV [%]


Test Date

Wet Feed
Dried Product
**CD26 Performance**

**Feed rate:** 75 tons/hr (14% of total)

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Feed TM %</th>
<th>Product TM %</th>
<th>Change TM % Abs</th>
<th>Change TM % Rel</th>
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</thead>
<tbody>
<tr>
<td>Average Total Moisture, TM</td>
<td>36.78</td>
<td>28.55</td>
<td>8.23</td>
<td>22.4</td>
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<tr>
<td>Std. Deviation</td>
<td>1.26</td>
<td>1.00</td>
<td>1.07</td>
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<tr>
<td>Std. Deviation of the Mean</td>
<td>0.34</td>
<td>0.27</td>
<td>0.30</td>
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<table>
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<tr>
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</thead>
<tbody>
<tr>
<td>Average HHV</td>
<td>6,290</td>
<td>7,043</td>
<td>752</td>
<td>12.0</td>
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<tr>
<td>Std. Deviation</td>
<td>159</td>
<td>121</td>
<td>131</td>
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<tr>
<td>Std. Deviation of the Mean</td>
<td>43</td>
<td>33</td>
<td>37</td>
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</table>
CD26 Performance

CD26: 75 t/hr

Moisture Reduction in CD26 [% Abs]

Fluidization Air Temperature [Deg. F]

Target

Simulation
Test Data
Unit Performance
### Unit Performance: Summary

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Units</th>
<th>Coal Dryer in Service</th>
<th>Coal Dryer Out of Service</th>
<th>Change</th>
<th>Units of Change</th>
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<tbody>
<tr>
<td>Gross Power Output</td>
<td>MW</td>
<td>589</td>
<td>590</td>
<td>NC</td>
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<tr>
<td>Throttle Steam Temperature</td>
<td>Deg. F</td>
<td>988</td>
<td>989</td>
<td>NC</td>
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<td>Reheat Steam Temperature</td>
<td>Deg. F</td>
<td>1,002</td>
<td>1,002</td>
<td>NC</td>
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<tr>
<td>SHT Spray Flow</td>
<td>klbs/hr</td>
<td>46</td>
<td>52</td>
<td>-6.4</td>
<td>klbs/hr</td>
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<tr>
<td>Total Coal Flow Rate</td>
<td>klbs/hr</td>
<td>953</td>
<td>972</td>
<td>-2.02%</td>
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<tr>
<td>Dried Coal</td>
<td>% of Total</td>
<td>14.62</td>
<td>0.00</td>
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<tr>
<td>Stack Flow Rate</td>
<td>kscfm</td>
<td>1,611</td>
<td>1,626</td>
<td>-0.96%</td>
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<tr>
<td>Specific Pulverizer Work</td>
<td>kJ/klb</td>
<td>4.09</td>
<td>4.29</td>
<td>-4.65%</td>
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<tr>
<td>Total Pulverizer Power</td>
<td>kW</td>
<td>4,057</td>
<td>4,206</td>
<td>-3.53%</td>
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<tr>
<td>NOx Mass Emissions</td>
<td>lb/hr</td>
<td>1,345</td>
<td>1,470</td>
<td>-8.52%</td>
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<td>SOx Mass Emissions</td>
<td>lb/hr</td>
<td>3,618</td>
<td>3,692</td>
<td>-2.00%</td>
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<td>APH 21 Gas Exit Temperature</td>
<td>Deg. F</td>
<td>353</td>
<td>362</td>
<td>-8.6</td>
<td>Deg. F</td>
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<tr>
<td>APH 22 Gas Exit Temperature</td>
<td>Deg. F</td>
<td>368</td>
<td>377</td>
<td>-9.3</td>
<td>Deg. F</td>
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<td>Stack Temperature</td>
<td>Deg. F</td>
<td>180</td>
<td>184</td>
<td>-4.2</td>
<td>Deg. F</td>
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</tbody>
</table>
Mill Power Reduction

CD26: 75 t/hr

- Test Data
- Theory
- Poly. (Theory)
Decrease in APH Gas Outlet Temperature

Improvement in Unit Performance

Reduction in Total Moisture in Fuel [% Abs]

Change in Flue Gas Temperature at APH Exit [Deg. F]

Theory
APH 21
APH 22
Boiler Efficiency Improvement

![Graph showing the relationship between reduction in total moisture in coal and boiler efficiency improvement. The graph includes theoretical and test result data points.](image)

- **Boiler Efficiency Improvement [% Abs]**
- **Reduction in Total Moisture in Coal [% Abs]**

**Legend:**
- Theory
- Test Result
Unit Performance Improvement

![Graph showing the relationship between reduction in total moisture in fuel and improvement in net unit heat rate. The graph includes a blue line representing theory and yellow squares representing test results.](image-url)
Test Data
Test Data: Coal Flow Rate

Prototype Dryer Performance Tests: March-April, 2006

Test Number

Total Coal Flow Rate [klbs/hr]

Coal dryer in service
Coal dryer not in operation
Test Data: Total Mill Power

Prototype Dryer Performance Tests: March-April, 2006

- Test Number
- Total Pulverizer Power [kW]

Lines:
- Blue: Coal dryer not in operation
- Green: Coal dryer in service
Test Data: $\text{NO}_x$ Emissions

Prototype Dryer Performance Tests: March-April, 2006

- Coal dryer not in operation
- Coal dryer in service

NO$_x$ Mass Emissions [lb/hr]

Test Number
Evaporated Coal Moisture Discharged into the Atmosphere
Conclusions

- Prototype coal dryer (CD26) in service at Coal Creek since early spring 2006.
  - No operating issues
  - Nominal coal flow rate 75/t/hr.
- Inlet moisture level reduced by 8.25% Abs.
- Coal flow rate reduction: 2.0%
- Mill power reduction: 4.5%
- Boiler efficiency improvement: 0.27% Abs.
- Net unit heat rate improvement: 0.34%
- NO\textsubscript{x} mass emissions reduction: 8.5%
- SO\textsubscript{x} mass emissions reduction: 2.0%
Future Work

- Operate CD26 at maximum capacity.
  - Determine operating conditions required to reduce inlet moisture level by 8.5% Abs.
- Determine effect on unit performance
- Construct and install additional three dryers in Phase 2.
  - Test to determine effect on unit performance, emissions, and operation.
Questions ?