Investigation of Coal Dust Mitigation Strategies

KY Professional Engineers in Mining Seminar
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Overview

• Importance of Coal Dust Mitigation
  – Changes to the coal dust regulations

• Dust mitigation technologies
  – Passive ‘Wing’ Regulator
  – Flooded Bed Scrubber for Longwall Shearer
  – Novel Vortecone Scrubber technology transfer

• Summary

• Acknowledgements
Trend in CWP through 2006

Percentage of examine miners with coal worker's pneumoconiosis (category 1/0+) by tenure in mining, 1970 – 2006 (NIOSH, 2008)
Changes to the Dust Regulations

1. Lowers the existing concentration limits for respirable dust in coal mines.
2. Mandatory use of a Continuous Personal Dust Monitor (CPDM).
3. Redefines the term “Normal Production Shift.”
4. Requires full shift sampling.
5. Change to the averaging method for compliance.
6. MSHA inspectors may use single, full-shift samples to gauge compliance.
Passive Wing Regulator

• Significant enhancement for blowing curtain face ventilation systems
  – Improved penetration of fresh air to the face
  – Improved dilution performance to lower dust exposure levels
• Improved dilution performance to lower methane levels

• Recent invention from UK colleagues
Flow Separation Phenomenon

• Only ~20% of the intake air makes it to the face for dust and methane dilution (Wala, 2001, 2004)
• Observed in both full scale, reduced scale models, and active mines
Flow Separation cont.

- Velocity readings at a typical blowing curtain face ventilation arrangement

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<table>
<thead>
<tr>
<th>Location</th>
<th>Velocity (m/s)</th>
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<tbody>
<tr>
<td>D3</td>
<td>0.117</td>
</tr>
<tr>
<td>D2</td>
<td>0.203</td>
</tr>
<tr>
<td>D1</td>
<td>0.249</td>
</tr>
<tr>
<td>C1</td>
<td>1.118</td>
</tr>
<tr>
<td>A</td>
<td>0.290</td>
</tr>
<tr>
<td>B2</td>
<td>0.279</td>
</tr>
<tr>
<td>B1</td>
<td>0.12</td>
</tr>
</tbody>
</table>
```

Diagram:
- 1.2 m height
- 12 m length
- 0.117 m/s
- 0.203 m/s
- 0.249 m/s
- 1.118 m/s
- 0.290 m/s
- 0.279 m/s
- 0.12 m/s

```
D3  D2  D1  C1
---- ---- ---- ----
0.117 0.203 0.249 1.118

A
0.290

B2
0.279

B1
0.12
```

2.2 m height
Passive ‘Wing’ Regulator

Solution to flow separation from concept to prototype
Jet Penetration Enhanced due to Wing Regulator

- Velocity readings with the wing regular applied to same blowing curtain face ventilation arrangement
Jet Penetration Enhanced due to Wing Regulator cont.

- Enhanced performance present with equipment at the face
Improved Dust Dilution with Wing Regulator

[Graph showing dust concentration change with and without Wing Regulator for Immediate Return, CM Operator, SC Operator 1, and SC Operator 2.]
Improved Methane Dilution with Wing Regulator
Flooded Bed Scrubber for Longwall Shearer

- Along dilution and water sprays, common dust capture technology for continuous miner units
- Needs to be adapted for longwall shearer
ACARP Project

- Following on from an Australian Project ending in 2009
- Compact modular scrubber added to the ranging arm
- Reduction in dust concentration from 14% to 56% measured outby from shearer operator

Figure 7. The installation of the final scrubber design
Field Trials
Conceptual Layout

- Duct / Demister
- Fan / Discharge
- Inlet / Flooded Bed
Preliminary Velocity Contours

File: full-face_900.fld
Cycle: 900
Time: 0.000000

Magnitude of Velocity [m/s]

0.0 - 8.0
Preliminary Velocity Contours cont.

File: full-face_900.fld
Cycle: 900
Time: 0.000000
Novel Vortecone Scrubber Technology Transfer

- Technology Transfer of a novel scrubber design
- NIOSH Funded Research
  - Recently awarded project – August 29
  - Five year research project
Conventional Scrubbers

- Cleaning efficiencies between 60% and 90% (NIOSH 1997)( USBM, 1990)
- Requires frequent maintenance to maintain performance
Paint Dust Challenge at Toyota

- Automotive manufacturers must scrub paint dust from the air
  - Paint application efficiency is between 50% and 60%, with particles from 1 to ~300 microns
  - OSHA requires a uniform downdraft velocity of at least 0.5 m/s within the painting area, (500 kcfm in total)
- The painting line consumes nearly 40% of the energy required to assemble an automobile
Vortecone Scrubber

- Currently operating in seven of Toyota’s plants to capture paint over-spray
- Cleaning efficiency of 99.6%
- 30% reduction in operating costs
- Greater system availability due to reduced maintenance frequency
Application to Fly Ash

- Feasibility study for capturing fly ash from flue gas from coal-fired power plants,
  - emphasis on the 2.5 micron size and smaller fraction
- Shawnee Power Plant fly ash, mean of 9.6 μm and a D_{50} of 7.7 μm
- 99.8% cleaning efficiency
Vortecone Scrubber for Mining

- Applicable for respirable size fraction
- High cleaning efficiency
- Minimal maintenance
- Scalable in match air requirements
  - From 200 cfm lab models to 60,000 cfm at Toyota
Summary

• Several new dust mitigation strategies under exploration at the University of Kentucky
  – For improved dust dilution
  – Potential for improved dust capture

• For follow ups
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Acknowledgement

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