Experimental Results of a Flooded-bed Dust Scrubber Integrated Within a Full Scale Longwall Shearer

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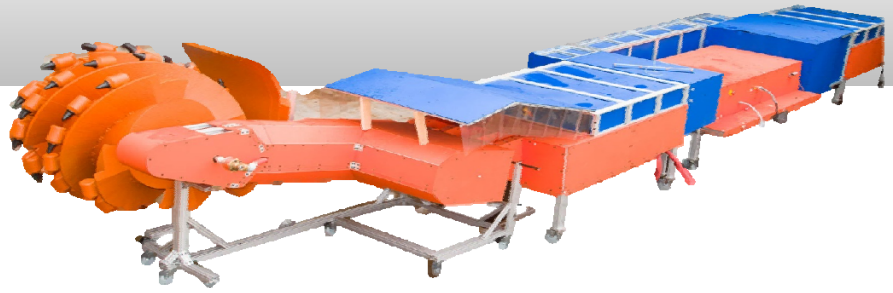


Outline

- Introduction
- Flooded-bed Scrubber
- Objectives
- Research Goals
  - Scrubber Design
  - Prototype Building
  - Laboratory Testing
- Results
- Conclusions

Introduction

- Dust generation at an underground working face is a health and safety issue
- Health
  - Prolonged exposure of airborne respirable dust can cause coal workers' pneumoconiosis (CWP) and silicosis
  - Black lung has killed more than 10,000 miners between 1995 and 2004 (NIOSH, 2008)

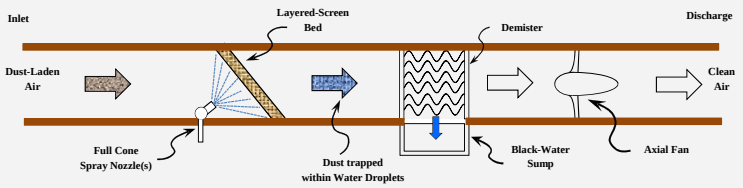
Introduction (cont.)

- Safety
  - The generated dust, if not captured, is deposited downwind on the return entries' surfaces
  - A methane explosion can trigger a coal dust explosion
    - Jim Walters No. 5 Mine
    - Upper Big Branch Mine

Introduction (cont.)

- Popular dust control techniques in an underground mine:
  - Dilution through ventilation air
  - Suppression by water sprays
  - Dust capturing through a machine mounted wet scrubber

Flooded-Bed Scrubber



Flooded bed scrubber system

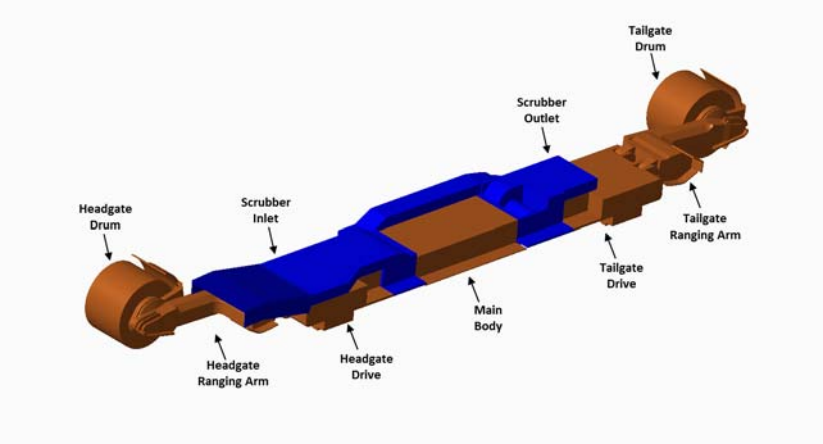
Flooded-Bed Scrubber (cont.)

- Performance measured by
  - Capture Efficiency
  - Cleaning Efficiency
- Capture efficiency 91%, 86%, and 40% on three different mines (Colinet et al., 2014)
- Can achieve a cleaning efficiency of 90% under its optimum conditions(NIOSH, 1997)

Objectives

- Reduce dust concentration at a longwall face
- Integrate a flooded-bed scrubber to a longwall shearer

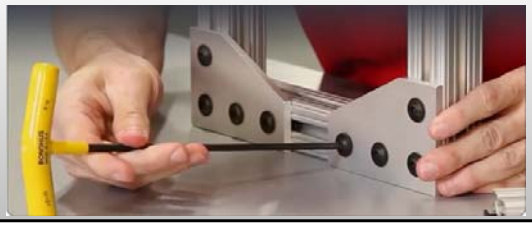
Scrubber Design (Modified Shearer)



Prototype Building

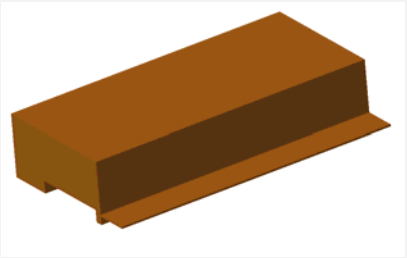
80/20 extrusion
Source: www.8020.net

80/20 brackets and fasteners
Source: www.8020.net



Prototype Building (Main Body)

1

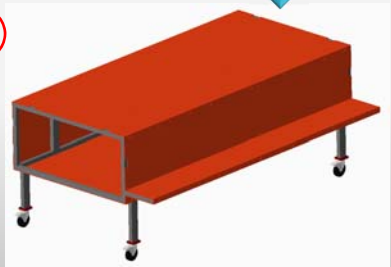


3-D Drawing

2

Metal Frame

3



Frame with plastic cover

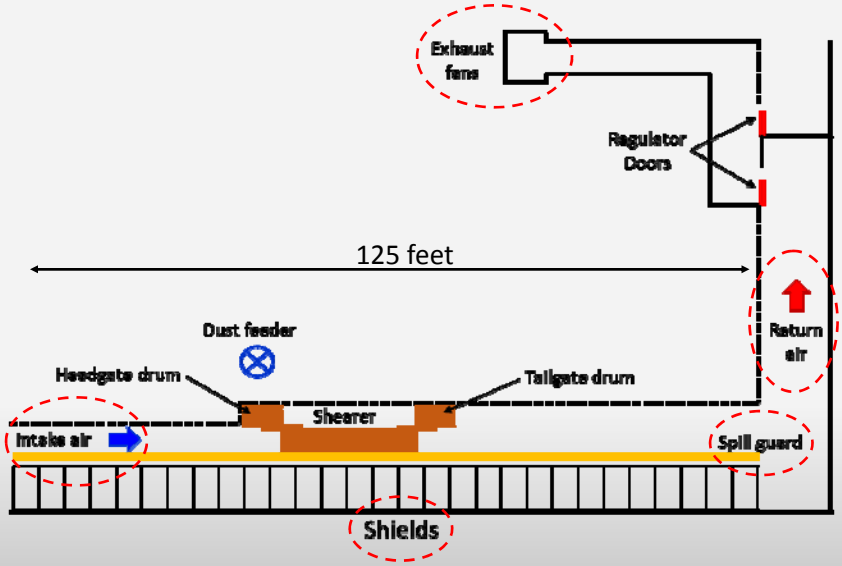
4

Final module

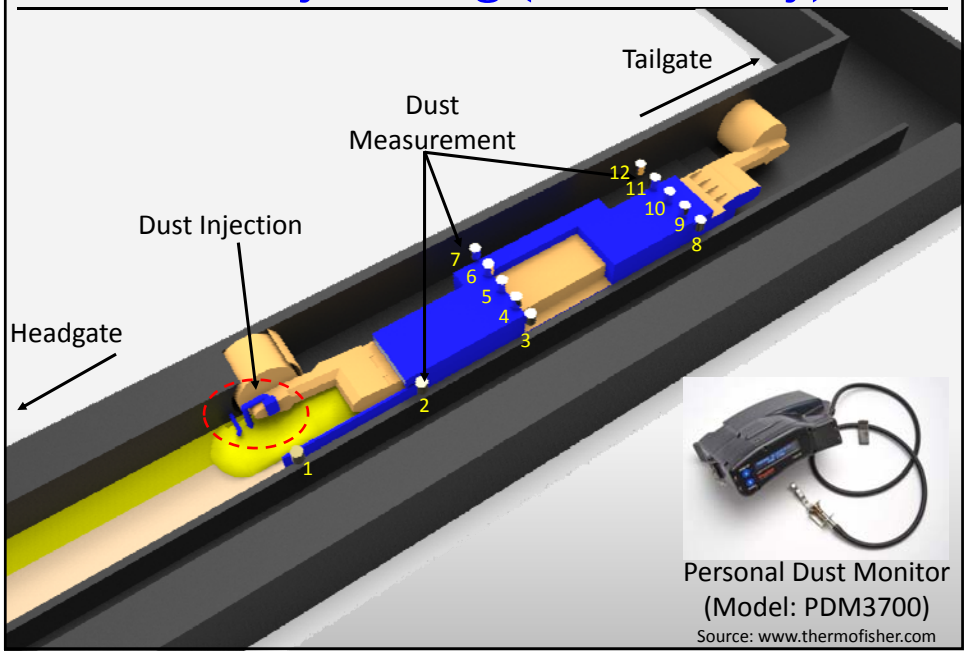
Prototype Building (Final)

Final prototype

Laboratory Testing (Test Gallery)



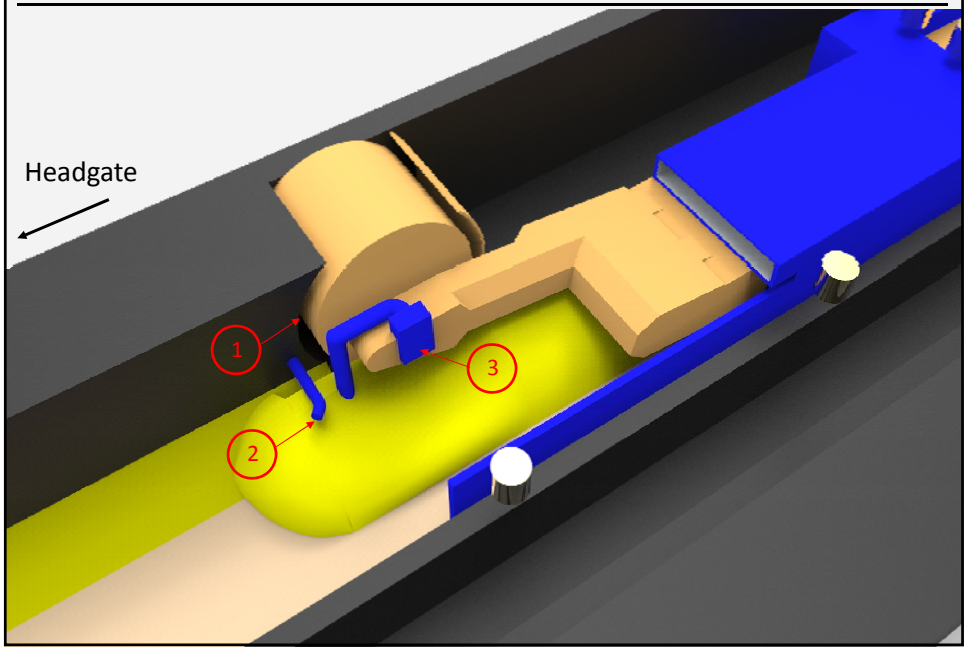
Laboratory Testing (Test Gallery)



Personal Dust Monitor (Model: PDM3700)

Source: www.thermofisher.com

Laboratory Testing (Dust Sources)



Laboratory Testing (Test Gallery)

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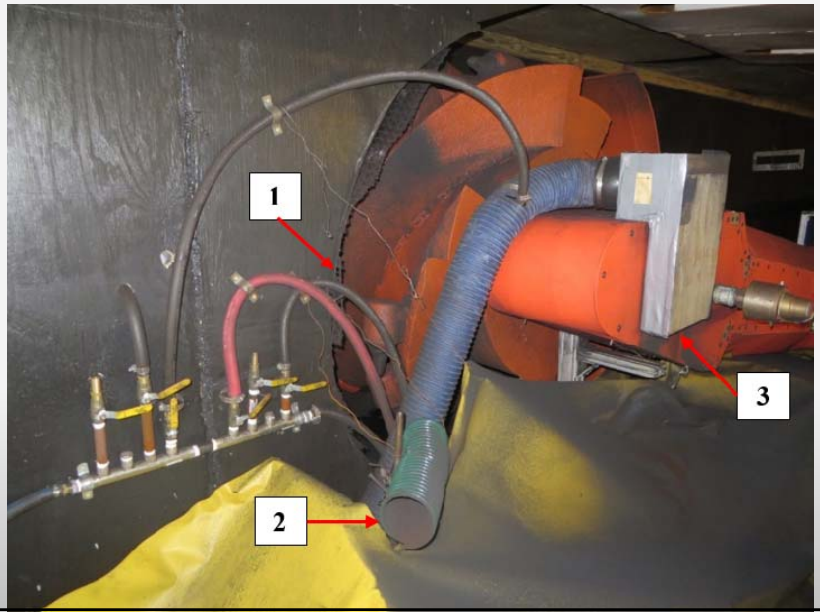
Laboratory Testing (Dust Sources)



Laboratory Testing (DOE)

Experimental Design (Factorial 2^k Design)

Factor	Low (-1)	High (+1)
Inlet extension (A)	OFF	ON
Scrubber quan. (B)	6,336 cfm (3 m^3/s)	13,700 cfm (6.46 m^3/s)
Face velocity (C)	500 fpm (2.54 m/s)	700 fpm (3.56 m/s)

Laboratory Testing (DOE)

Inlet Ext. (A)
Scrubber Quan. (B)
Face Vel. (C)

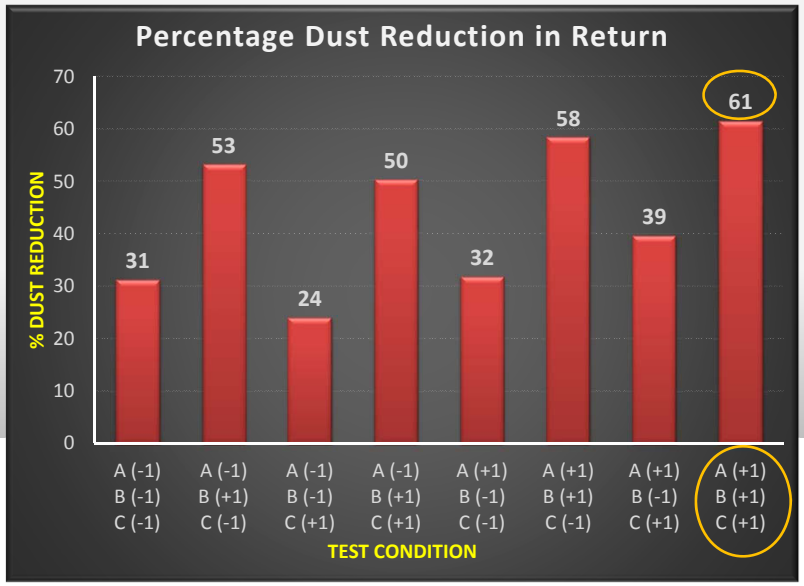
Low level (-1)
High Level (1)

Full factorial design

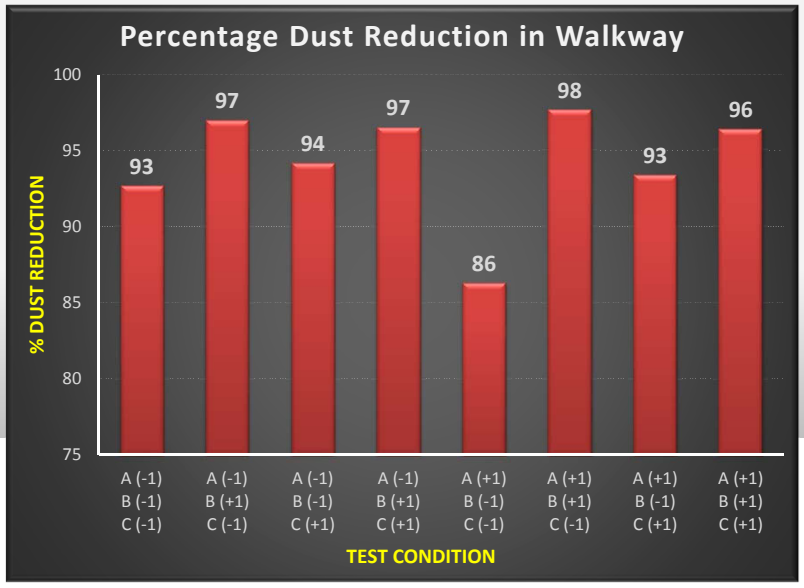
Experiment	Factors			Replication
	A	B	C	
1	-1	-1	-1	① ② ③ ④ ⑤
2	-1	-1	+1	① ② ③ ④ ⑤
3	-1	+1	-1	① ② ③ ④ ⑤
4	-1	+1	+1	① ② ③ ④ ⑤
5	+1	-1	-1	① ② ③ ④ ⑤
6	+1	-1	+1	① ② ③ ④ ⑤
7	+1	+1	-1	① ② ③ ④ ⑤
8	+1	+1	+1	① ② ③ ④ ⑤

40 Experiments

Results (Return)



Results (Walkway)



Data analysis (Regression Model)

Term	Estimate	Std Error	t-Ratio	P-Value
Intercept	43.64	0.58	74.7	**<.0001**
A	4.07	0.58	6.96	**<.0001**
B	12.10	0.58	20.71	**<.0001**
C	0.10	0.58	0.18	0.86
AB	0.03	0.58	0.05	0.96
AC	2.64	0.58	4.51	**<.0001**
BC	-0.03	0.58	-0.05	0.96
ABC	-1.14	0.58	-1.94	0.06

A → Inlet Extension, B → Scrubber Quantity; C → Face Velocity

$$\hat{y} = 43.64 + 4.07A + 12.10B + 2.64AC$$

Model → **62.45% Reduction**

Experiment → **61.42% Reduction**

Conclusions

- Emulating the success of flooded-bed scrubber
- Design of a flooded-bed scrubber, Physical model fabrication, Laboratory testing
- A maximum 96% and 62% dust reduction in the walkway and return respectively
- Scrubber quantity is the most significant factor, followed by the inlet extension