Min-218
Mine Atmospheric Control
– Principles, Analysis, and Design –

Purpose:
To provide air to sustain and protect miners and make the work environment as comfortable as feasible;
To prevent deterioration of conditions or protect infrastructure.

Ultimate Challenge
Providing adequate air and comfort (meeting regulatory and organizational requirements) to miners working at great depth at reasonable cost.
Coordination of Mining and Ventilation Systems

- Consider role vs. production and cost
- Need to integrate considerations as total mine system is optimized under realistic constraints
- Better able to do this today because of computing advances and robust modeling capability that can consider social, political, economic, and environmental consequences

Foundations of Mine Ventilation and Air Conditioning

- Physical chemistry, thermodynamics, fluid mechanics and mechanical design
- Mining methods; awareness of mining technology

Mine Ventilation Principles, Planning, and Tools Have not Changed in the Last 50 Years Except for the Computers, Which Were not around Yet

Why?

Because Mine Ventilation Is as Old as Mining, Several Thousand Years Old, and the Problems Have not Changed
Some Benchmarks in Mining Literature

- Archimedes of Syracuse: 287-212 B.C.;
- Hero of Alexandria: 3rd-2nd B.C.;
- Pollio Vitruvius, Rome: 1st B.C., Engineering Encyclopedia;
- Pliny the Elder, Rome: 23-72 AD, Natural History (37 Vol., 4 on Mining);
- Roger Bacon/Albertus Magnus, 13th AD: Translations of Writing of Classics

Invention of Printing: 1436

- 1485-1500: 2 Books on Mining
- 1500-1510: 4 Books on Mining
- 1510-1600: 17 Books on Mining

- First Book “Iudicium Iovis,” 1485: Environmental Concerns, Other Books Don’t Have Many Details;
- Agricola, 1530: De Re Metallica
- Sinclair, 1672: History of Coal Mining
“The Effect of Natural Ventilation” (1550)

“Old-fashioned Exhaust Device” (1550)

“History of Coal Mining” - by Sinclair (1672)
Ventilation Furnaces

Surface furnace Bartels (1711)
Underground furnace Wallsend Pit (1787)

Benchmarks in Ventilation Equipment after Agricola

- Natural ventilation heating baskets: 1650
- Surface chimneys: 1665
- Pumps: 1711
- Water jets: 1719
- Ventilation furnace underground: 1787
- Steam engine as fan drive: 1796
- Steam jets: 1811

Benchmarks in Ventilation Equipment after Agricola

- Centrifugal Fan: 1827
- Axial Flow Fan, Cooling Plants: 1920s
- Analog Computers: 1940s
- Digital Computers: 1950s
- Handheld Methanometers: 1950s
- CO Self-Rescuer: 1950
Benchmarks for Ventilation Theory

- 17th Century: Discovery of scalar nature of pressure, calculus, Newton’s 2nd Law;
- 18th Century: Derivation of Euler’s (Turbine) equation & Bernoulli’s equation
- 19th Century: Derivation of shock loss (Borda-Carnot) eq.; formulation of Atkinson’s (Darcy-Weisbach) eq.; ventilation network calculations; first network calculations for complex networks using iteration methods (1854)

Pressure Survey

- If existing airways become part of a new, planned ventilation system, their resistance have to be determined thru either calculation or pressure survey;
- The instruments used in pressure surveys have not changed much over the last century, except for the barometers.

Temperature Pre-calculations

- 1822 – Fourier, Jean B.J.: Theorie Analytique de la Chaleur;
- 1926 – Temperature changes in airways with harmonic temperature variations at airway beginning, considering rock walls as plane surfaces;
- 1951 – Same as above, considering airways as hollow cylinders.
Ventilation Network Calculations in the 1950s

The mathematical description of networks was well known, the problems rested in the execution of the calculations required for a solution.

- Computers available;
- Electrical filament bulb analog;
- National Coal Board Network Analyzer;
- The first fully automatic electromechanical ventilation network analog computers.

Manual Network Calculations

- Condense networks by combining the airways in series and parallel;
- The condensed network – using trial and error method:
  - Step 1: Assume an airflow distribution which satisfies the node equations;
  - Step 2: Calculate branch pressure losses;
  - Step 3: Check mesh eq, if not satisfied move air from airways with too large pressure losses to airways with too low pressure losses;
  - Repeat steps 1–3 until node and mesh eq. are satisfied.

Optimizing Ventilation Planning

A desired increase of airflow rates can be accomplished by:

- Detection and removal of avoidable shock losses;
- Detection and remedy of bottle-necks in cross-sectional areas;
- Reactivation of old, seal-off mine workings for ventilation; and
- Fan speed change.
Ventilation in the Last 50 Years

» The biggest change: Computers!
» Reliable and versatile instruments for analyzing ventilation properties and data acquisition;
» The use of computer and instruments allow data processing and ventilation network model building, that have greatly facilitated the problem solving and mine design.