Evaluation and Production Models for Coal Mine Methane Control and Utilization

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Content of this presentation

Discuss challenges in coal mine methane control and production for safety and utilization

Present the new NIOSH “Methane Control and Prediction (MCP)” software suite.

- Scope of the software suite
- Model development strategy
- Installation and running the software
- Applications of the models and some results
Schematics of a longwall mine
Schematics of face ventilation

The optimum quantity of ventilation air for the mine?
Amount of VAM to capture and utilize?
Auxiliary methane control

The best degasification option?
Gob gas ventholes

Production rate: ?
Methane %: ?

- Gassiness sandstone
- Rider coal seam
- Fractures extending to overlying strata
- Bedding plane separations
- Shale
- Slotted casing
- Air leakage
- Fracturing and caving
- Roof support?:
- Gas control?:

Surface
GGV blower and engine
Mining height
Establishing the need for this software

Coal mine methane control and production is challenging.

Proven numerical simulation techniques are time consuming, difficult and require expertise to use.

Most coal mine operators, gas producers and project developers have to respond to rapidly developing situations.
Establishing the need for this software

This software is intended to fill the gap between complex numerical simulation methods and trial-and-error based guesses by offering:

- Accurate predictions using limited number of inputs
- User friendly interface and prediction models
- Predictions to problems of great interest for mine safety and coal mine methane recovery
- Possibilities to find out the trends in real-life problems and sensitivities of results to various inputs.
Model development

- Real data augmented by numerical model results were compiled.
- Data were processed by different statistical and mathematical approaches.
- Models were built using prediction and classification artificial neural networks.
- Executable dynamic link libraries (DLLs) were developed using C++ to work with MS-Access.
- All DLLs were combined under a single user interface developed with MS-Access shell programming.
Model validation

- The technical approach was peer-reviewed and published in reputable scientific journals.

- The DLLs and the software were tested in-house for functionality, ease of use and accuracy by using testing data.

- It has been evaluated by several industry experts and academicians for its usefulness and technical quality.

- Feedbacks to this version will be used for developing the next version with added prediction modules.
**Installation of the software and files**

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Running the software

Title page

From the desktop icon

From the directory
Help documentation

- General description of the software and input/output parameters
- Accessible from title page and from each module
User manual to version 1.1

- Stand-alone .pdf file
- Includes technical details of each module and their development
Prediction modules in the software suite

Current version of the software contains four modules.
Module 1
Coal measure rock mechanical properties

Purpose of the model:

☑️ Create an alternative to a full-wave sonic log, which is data intensive and time consuming to process

☑️ Outputs are used for strata fracturing and gob caving assessment for gas control and roof support
Module 1
Coal measure rock mechanical properties

Full wave sonic log that needs to be processed for sonic transit times to calculate rock elastic properties
Module 1
Coal measure rock mechanical properties

- Inputs are gamma ray and density log readings
Module 1
Coal measure rock mechanical properties

- Outputs are shear modulus and Young’s modulus
- Bulk modulus and Poisson’s ratio can be calculated

\[ E = 2G(1 + \nu) \]
\[ K = \frac{E}{3(1 - 2\nu)} \]
Module 1
Applications and sensitivity studies

Limestone, sandstone

Clay, shale, coal
Module 1
Applications and sensitivity studies

Clay, shale

Sandstone, Limestone
Module 2
Mine ventilation system emission model

Purpose of the model:

☞ How much VAM a particular mine can produce?
☞ How much air should be provided?
☞ Amount of released methane for environmental concerns.
☞ Earning credits and identifying opportunities for VAM capture and utilization.
Module 2
Mine ventilation system emission model

- Limited number of input parameters from various “groups”

Location
Geologic
Operational
Gas content
Productivity
Module 2
Mine ventilation system emission model

Predicted emission
Module 2
Applications and sensitivity studies

Expected ventilation methane emissions as a function of location, coal production and coal gas content
Module 2
Applications and sensitivity studies

Expected ventilation methane emissions as a function of seam height, panel width and coal gas content
Module 3
Degasification system selection model

Purpose of the model:

 Identify the need of a degasification system for a longwall operation.
 Help the selection of one or more degasification systems for given coal, mine operation, productivity and expected methane emissions.
 A screening tool before building complex models for borehole productivity analyses.
Module 3
Degasification system selection model

Follows a similar input structuring as the emission model
Module 3
Degasification system selection model

Output probabilities are mapped on four different classes. A recommendation is provided based on probabilities.
Module 3
Applications and sensitivity studies

Suggested degasification options as a function of VAM, coal production and overburden
Module 3
Applications and sensitivity studies

Suggested degasification options as a function of cut height, panel width and coal gas content
Module 4
Gob gas venthole performance prediction

Purpose of the model:

- Maximize production rates
- Determine and optimize methane concentration in gas
- Improve mining safety
- Produce pipeline quality gas
Module 4
Gob gas venthole performance prediction

Inputs were selected based on most important parameters relevant to gob gas venthole performance
Module 4
Gob gas venthole performance prediction

Panel completion and mining rate
Depth of well
Well completion
Location over panel
Panel dimension
Gas removal

Completed
Active
Idle
Advancing
Module 4
Gob gas venthole performance prediction

![NIOSH Methane Prediction Models](image)

**Input Parameters**
- Total production rate
- Methane percent

**Input Values:**
- Is Panel Completed?: Active
- Is There Face Advance?: Advancing
- % of Panel Completed: 80
- Linear Advance Rate (ft/day): 60
- Surface Elevation (ft): 1050
- Average Overburden (ft): 800
- Casing Diameter (inch): 7
- Distance of Slotted Casing Bottom to Coal Top (ft): 40
- Distance to Tailgate (ft): 250
- Distance from Panel Start (ft): 370
- Panel Length (ft): 11000
- Panel Width (ft): 1250
- Barometric Pressure (in Hg): 28.1
- Average Exhaustor Vacuum (in Water): -43

**Output:**
- GGV Prod (scfm): 316.3122
- Methane Conc (%): 55.6583
Module 4
Applications and sensitivity studies (Active – Adv.)

Total gas production rate as a function of linear face advance, panel length and GGV distance from start
Module 4
Applications and sensitivity studies (Active – Adv.)

Methane concentration as a function of linear face advance, panel length and GGV distance from start
Total gas production rate as a function of extraction vacuum, panel width and distance of bottom of slotted casing to top of coal bed.
Methane concentration as a function of extraction vacuum, panel width and distance of bottom of slotted casing to top of coal bed.
Summary and conclusions

- NIOSH’s MCP software has been introduced along with its scope and development strategy

- MCP identifies:
  - The elastic dynamic properties of coal-measure rocks
  - The total ventilation methane output of a longwall mine
  - The best way to degasify a longwall mine using proven techniques
  - Performance of the GGVs for safety and the possibility of utilizing produced gas.
Summary and conclusions

- Currently there are no simple ways to estimate and plan for methane drainage and emissions. The MCP software is a new practical tool.

- The applications of the MCP software modules will help improve safety of mines. MCP will also help to identify opportunities for capturing and utilizing methane.

- Modules will also provide some of the inputs to U.S. EPA CMOP’s coal mine methane cash flow model.
Thank you

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