Technology News

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SPONCOM—AN EXPERT SYSTEM TO PREDICT SPONTANEOUS COMBUSTION POTENTIAL OF A COAL MINING OPERATION

Objective

Predict the spontaneous combustion potential of a mining operation using an expert system computer program.

Background

Approximately 15% of underground coal mine fires are caused by the spontaneous combustion of coal. Spontaneous combustion fires usually occur in mined-out or gob areas and are difficult to detect and to extinguish. These fires present a serious safety hazard to mine personnel, often requiring sealing of large sections of the mine or the entire mine. A knowledge of the spontaneous combustion potential of the mining operation and the factors that increase that risk can be useful in preventing spontaneous combustion fires. This can be accomplished through the use of aggressive monitoring and control measures at existing coal mining operations.

The self-heating of coal occurs when the heat produced by low-temperature oxidation is not adequately dissipated, resulting in a net temperature increase in the coal mass. Under conditions that favor a high heating rate, a fire ensues. Many factors can contribute to the spontaneous combustion process in an underground mining operation. These include the self-heating potential of the coal, the coal properties, the geologic and mining conditions, and the mining practices.

Approach

The SPONCOM expert system was developed by the U.S. Bureau of Mines (USBM) to aid USBM and U.S. Mine Safety and Health Administration personnel, mining operators, and consultants in the assessment of the spontaneous combustion risk of an underground mining operation. An expert system is a computer program that uses available information to make decisions based on a series of rules provided by the programmer. It is an interactive, user-friendly, and inexpensive method of conveying "expert" advice.

To develop the program, information was gathered from the literature, from interactions with experts in ground control, ventilation, and geology, and from mine personnel that have experienced self-heating events at their operations. The information was correlated with the USBM's experimental studies on the self-heating tendencies of coals to form the knowledge base for the expert system.

How It Works

The program is designed to obtain information from the user on the coal properties, geologic conditions, mining conditions and practices, and spontaneous combustion history for a mining operation. The program uses a series of interactive data-input screens to prompt the user. During the input process, "expand" screens are available to provide specific information on each input parameter with respect to its particular effect on the overall self-heating risk.

The program, written in ANSI C programming language, determines the coal's rank and relative self-heating potential, based on the coal's proximate and ultimate analyses, heating value, and prior spontaneous combustion history. The program then determines what effects the coal properties, geologic and mining conditions, and mining practices have on the spontaneous combustion risk of the mining operation, based on the coal's self-heating potential.

Two mechanisms contribute to the heat generation by the coal, the heat of oxidation and the heat of wetting. The heat of oxidation is the heat generated by the adsorption of oxygen by the coal. The reaction rate is temperature dependent, increasing with increasing temperature. The heat of wetting is the heat generated by the adsorption of water vapor by the coal surfaces. Coal properties that affect the rate of heat generation include the coal's reactivity, its moisture content, friability, and the presence of pyrite and other impurities. The friability of coal is a measure of its ability to be broken into smaller pieces. While the friability of coal is not a heat-producing property, more friable coals have a higher relative self-heating risk because of the generation of fresh surfaces available for oxidation and heat of wetting to occur. The program determines the contribution of each of these factors to the overall spontaneous combustion risk.

Geologic factors that are included in the program's evaluation of the spontaneous combustion risk include those that affect the amount of coal exposed to air and moisture, such as coal thickness, seam gradient, dikes, and cleat density, and those that affect the reactivity of the coal, such as the presence of geothermal sources and natural burn zones. Also included are geologic factors that affect the transport of air and moisture to the coalbed, such as depth of cover, faults, dikes, and channel deposits. In addition, the presence of pyrite veins and rider beds in close proximity to the coal seam, which can also react with air and moisture, increasing the spontaneous combustion risk, is considered.

The mining conditions section of SPONCOM evaluates the effects of mining conditions on the overall spontaneous combustion risk of the mining operation. Among the conditions considered are the degree of floor heave, which can expose rider beds or pyrite veins that might be present to air and moisture. The amount of rib sloughage, which contributes to the amount of exposed coal surfaces susceptible to oxidation in the mine entries, is also considered. The effect of the ambient air temperature in the working area is also evaluated, since the reaction rate of the coal oxidation is directly related to temperature.

The final section of SPONCOM assesses the effects of mining practices on the spontaneous combustion risk. The mining practices are the only factors that can be directly controlled by the operator. The type of mining (longwall or continuous), gate road pillar design, panel dimensions, coal thickness being mined, and rate of advance or retreat are all important factors in determining the spontaneous combustion potential of a mining operation. These factors control the amount of coal exposed to air and moisture and the duration of the exposure. Other factors considered in this section are the face ventilation air velocities and the caving height of the gob. These factors influence the movement of air and moisture in the gob or mined-out area.

The input data are stored to a data file, where it can be recalled and updated as needed. The program output gives the self-heating risk of the coal and provides details on each of the factors that increase the risk of spontaneous combustion in the mining operation. These are displayed on the terminal and can be printed to a hard-copy printer.

This information can be useful in preventing spontaneous combustion fires through the use of aggressive monitoring and control measures at the mining operation.

For More Information

To obtain a copy of the expert system program (on a 3½-inch diskette for IBM[1] personal computers or compatibles) or for more information about the USBM's spontaneous combustion research program, contact: Alex C. Smith, Pittsburgh Research Center, U.S. Bureau of Mines, Cochrans Mill Rd., P.O. Box 18070, Pittsburgh, PA, 15236, telephone (412) 892-6766.

[1]Reference to specific products does not imply endorsement by the U.S. Bureau of Mines.