SEAM GAS DRAINAGE AS A MEANS OF OUTBURST CONTROL

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ABSTRACT

Outbursts of coal and gas are coupled both in their nature and mechanism and take place under varied sets of physical and geological conditions. The main interacting factors are geology and seam structure, seam gas composition and pressure and strata stress.

By pre-draining the seam gas in advance of workings one of the factors contributing to outbursts is removed. One method of pre-draining gas from the coal seam or from areas of geological disturbance is to drill long horizontal holes in the coal seam.

The technology to drill horizontal holes up to 600 m in the coal seam is now available by hydraulic control of the rotation and thrust on the drill bit and accurate survey methods to determine the vertical and horizontal position of the drill bit.

INTRODUCTION

The problem of outbursts is one which has existed in many coal mining areas of the world and a successful solution to this problem has baffled scientists and engineers since the beginning of the century. Whilst no universal solution has been found, considerable knowledge has been gained and defensive measures devised to allow mining to proceed with satisfactory safety and production limits.

Defensive methods used to control outbursts in Australian coal mines have included prediction or early warning methods by measuring the gas desorption rate of the coal and preventive methods by drilling large diameter holes up to 4 m in advance of continuous miner development and inducer shot-firing for conventional mining methods. These methods have suffered a serious disadvantage in low production rates due to frequent interruptions to the production cycle to measure the seam gas desorption rate or to drill advance drainage holes.

Japanese mines have been successful in eliminating outbursts in some of their mines by pre-draining the methane gas from the coal seam in advance and allowing up to 2 months for the gas to drain.

Following over 10 years of research, the U.S. Bureau of Mines has developed methane drainage technology to the stage where it is now a part of the mining cycle and is used to improve the face ventilation by reducing the methane concentrations.

The objective of ACIRL's outburst and methane drainage research program is to develop a positive method of control by pre-draining the seam gas either by long horizontal holes in the seam or by surface holes and allowing sufficient time for the gas to be drained. The successful pre-draining of the seam should result in a reduction or elimination of outbursts similar to experience in Japan.

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OUTBURSTS

As Australian mines have progressed deeper in the development of mines the incidence of outbursts has become more common. Occurrences have been recorded at Collinsville, Blackwater and Moura in the Bowen Basin of Queensland, and also in a number of mines working the Bulli seam on the Southern coal fields of N.S.W. The nature of these occurrences has been dissimilar in geological environment and composition of seam gas. The solution is, therefore, a complex and difficult problem, and it is likely that no single factor will be isolated as the cause in all situations. It is generally accepted that factors which contribute to outbursts are :

(a) Gas content of the seam
(b) Structure and nature of the coal
(c) Geological features
(d) Stress environment

If one or any combination of these factors change from normal or the equilibrium is disturbed during mining, a potential outburst situation may result.

The structure and nature of the coal seam and the geological features are fixed or permanent and, therefore, it is logical that control measures have concentrated on reducing the seam gas and stress environment.

CONTROL OF OUTBURSTS

A number of defensive methods have been developed to allow coal mining to proceed with safety. These methods can be divided into passive or positive control. The passive control methods can be described as early warning of impending outburst situations and include routine measurement of the gas desorption rate of the coal and seismic acoustic methods. Positive methods for the control of outbursts have been developed to reduce or eliminate the possible incidence of outbursts and include -

(a) Seam gas drainage
(b) Inducer shot-firing
(c) Water infusion
(d) Mining an adjacent upper seam first

The most general method for control of outbursts in Queensland has been seam gas drainage by advance drilling of large diameter boreholes. This method was used extensively at Leichhardt Colliery until the major outburst in 1978. In New South Wales inducer shot-firing has been used successfully at Metropolitan colliery.

OVERSEAS PRACTICE

Experience in Japanese mines has shown that methane drainage in advance of mining has reduced, and in some cases, eliminated outbursts. Various Japanese workers (KODAMA, 1972; HIGUCHI, 1979;) have shown that up to 65% of the seam gas is extracted before mining.

At Sunagawa mine before development in coal starts, gas drainage holes 80 mm diameter are drilled from the cross-cut to intersect the seam to form a 15 m grid pattern and each hole is connected to the gas suction main for one week. The gas main has a negative pressure of 150 mm of Hg. Approximately 25% of the gas is extracted by boreholes from the seam before mining. When the gas flow equals 50 L per minute, it is considered safe to extract the coal without danger from outbursts.

At Akabira mine a similar methane extraction method to the Sunagawa mine is practised. Gas outbursts occurred at the face before gas drainage was installed, but since introducing the methane drainage program no outbursts have occurred. The coal seam contains 20 m^3 per tonne at pressures up to 255 Pascals. Up to 65% of the gas is extracted by pre-draining which takes a period of approximately 2 months.

At Minami Ouybari mine the coal seam contains 70 m^3 per tonne of which an average

of 52% is extracted before mining at the rate of 5 to 10 m^3/minute. No outbursts have occurred since the pre-draining commenced. At each of these Japanese mines the present practice has been developed from many years of experience and their engineers stress that the system of methane drainage only applied to each mine and was not transferable readily between mines.

In the United States of America the technology of methane drainage has progressed rapidly following extensive research by the U.S. Bureau of Mines. Several mines are now pre-draining in advance of mining. These mines include -

Loveridge
Sugar Run Portal
Federal No. 2
Virginia Pocahontas No.3 and No.5

At these mines, as part of the normal mining operations, two 80 mm diameter holes are drilled on each side of the development heading 300 m in advance and connected to gas drainage mains for piping to the surface. The technology to drill horizontal holes 300 m and up to 600 m in the coal seam has only been developed in the last three years. The drilling equipment and borehole survey technique are described in a later chapter.

DRILLING TECHNOLOGY

The basic requirements for drilling accurate holes within the confines of the coal seam are separate power source for the drill rotation and thrust so that the rate of rotation and thrust of the drill bit can be varied independently.

For holes up to 100 m the Atlas Copco Diamec 250 drill is used by both ACIRL and West Cliff colliery for methane drainage. This rig was originally developed for use in metal mines for drilling blast holes, grout injection and obtaining core samples. The drill has proved satisfactory for methane drainage due to its high penetration rate in coal and convenient drill rod handling capabilities. The maximum length of holes achieved with this rig without a bit survey has been 120 m. At this distance the drill bit usually intersects the floor of the seam due to the weight of the drill string causing a downward trajectory. It is expected that the maximum distance will increase in the future as the drilling crews accumulate more experience in adjustment of thrust and rotation of the drill bit and variations in the placement of stabilisers. The main disadvantage of the drill is the large quantity of compressed air(250 L/s) required to drive the compressed air motor and this quantity is often not available in collieries.

For holes up to 600 m in length two drilling machines are now commercially available in the United States of America.

These are -

1. Acker Big John degasification drill
2. Fletcher degasification drill

Both of these drills are being used in the U.S. mines for advance methane drainage of development headings. ACIRL will take delivery of an Acker Big John drill in July 1980 and this unit will be used to develop the techniques for drilling gas drainage holes up to 600 m in the coal seam.

In order to maintain horizontal control when drilling long horizontal holes it is necessary to measure the direction and inclination of the advancing borehole. A borehole survey instrument used for this purpose is an Eastman single shot survey tool. The basic instrument has a tube diameter of 31 mm and length of 1 metre and consists of a watch and camera section and an angle unit with a fluid dampened compass and a plumb bob suspended on gimbals. This section is inserted in a protective case 33 mm diameter.

To take a borehole survey reading the survey instrument is pushed up the hollow drill rod by water pressure to the end of the drill string and after a pre-determined time interval the camera takes a photograph of the compass. The instrument is then withdrawn from the drill string by a trailing wireline and the photographic disc is developed on the spot to give the inclination and bearing at the end of the borehole. Corrections are then made to the operation of the drill according to whether the drill bit is rising or falling in the seam. The operational drilling parameters established by the U.S. Bureauof Mines for changing the direction of the drill bit are :

1. The drill assembly consisted of 82 mm drag bit welded to a stabiliser followed by 6 m of drill collar followed by another stabiliser. To start the drilling operation the drill was located in the centre of the seam and a horizontal hole drilled using (404N to 450N) thrust on the bit and rotation maintained at 250 rpm.

2. To cause the trajectory of the drill bit to rise, the thrust is increased to 674N (3000 lbs), and the rotation was reduced to 150 rpm.

3. To cause the trajectory of the drill bit to fall in the seam the thrust was reduced to 224N at the bit and the rotation increased to 400 rpm.

ACIRL's RESEARCH PROGRAM

ACIRL's current research program for methane drainage and outburst control is based on combining the successful Japanese mining experience of pre-draining the methane gas before mining and the advanced drilling technology of the United States to drill long horizontal holes in the coal seam. An ACKER BIG JOHN degasification drill will be used later this year by ACIRL to drill holes up to 600 m in advance of development headings to pre-drain the methane in advance of mining. Initial work will be to drill advance holes in the outside headings of a three heading development and then measure the pressure drop in a central borehole. Further work will study the effects of flow rates with applied suction and stimulation of the borehole by hydrofracturing.

The objective is to not only improve face ventilation by reducing the gas concentrations at the face but to drain any pockets of gas which may accumulate in permeable zones at geological anomalies and to reduce the gas pressure which may lead to an outburst condition.

One of the disadvantages in degassing the seam in advance with present methods is the limited depth of holes which can be drilled, and the frequent delays to production while the holes are drilled and allowing sufficient time for the gas to drain. The ability to drill holes up to 600 m in advance of development should eliminate this disadvantage by providing an increased length of degassed seam ahead of mining. It may also be possible to reduce the time required to drain the methane by applying suction to the drainage holes. Results from current research by ACIRL and CSIRO at West Cliff (Levers, unpublished data 1980) have shown that the flow of methane increased up to five times free flow conditions when a suction of 10 kPa was applied to the borehole.

CONCLUSION

Unlike overseas countries methane drainage has not been widely practised in Australia where it has been regarded as restricting production. It is only in the past three years that serious attempts have been made to develop methane drainage as an integral part of the coal mining program.

Drilling technology and equipment have improved rapidly in recent years resulting in

more rapid drilling of the drainage holes.

Further work by the U.S. Bureau of Mines in improving borehole survey techniques to allow continuous drilling will mean even faster drilling rates in the future. Even with faster drilling, mine planning will need to be carefully designed to allow sufficient time for an area to be degassed before mining commences in that area.

It is not suggested that seam gas drainage will be successful in eliminating outbursts at all mines, but early results are encouraging, and if successful, will have wide application as a positive control method in outburst prone coal mines in Australia.

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