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Quick determination of gas pressure before uncovering coal in cross-cuts and shafts

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Abstract: The determination of gas pressure before uncovering coal in cross-cuts and in shafts is one of the important steps in predicting coal and gas outbursts. However, the time spent for testing gas pressure is, at present, very long, seriously affecting the application of outburst prediction techniques in opening coal seams in cross-cuts and shafts. In order to reduce the time needed in gas pressure tests and to improve the accuracy of tests, we analyzed the process of gas pressure tests and examined the effect of the length of boreholes in coal seams in tests. The result shows that 1) the shorter the borehole, the easier the real pressure value of gas can be obtained and 2) the main factors affecting the time spent in gas pressure tests are the length of the borehole in coal seams, the gas emission time after the borehole has been formed and the quality of the borehole-sealing. The longer the length of the borehole, the longer the gas emission time and the larger the pressure-relief circle formed around the borehole, the longer the time needed for pressure tests. By controlling the length of the borehole in a test case in the Huainan mining area, and adopting a quick sealing technique using a sticky liquid method, the sealing quality was clearly improved and the gas emission time as well as the amount of gas discharged greatly decreased. Before the method described, the time required for the gas pressure to increase during the pressure test process, was more than 10 days. With our new method the required time is only 5 hours. In addition, the accuracy of the gas pressure test is greatly improved.
Key words: gas pressure; sticky liquid sealing; quick test; cross-cut; shaft

1 Introduction

With the increase of mining depth and mining intensity of coal in China, newly constructed shafts have become deeper and deeper, which quite easily induces dynamic gas phenomena, resulting in increasing numbers of accidents, killing or injuring coal miners. On January 5, 2006, a gas outburst occurred in Huainan Wangfenggang coal mine, killing 12 coal miners. On July 29, 2006, a gas and coal outburst occurred in clearing coal from a water pocket at the bottom of the auxiliary shaft of Mengjin coal mine, with a coal outburst volume of 900 t and a gas volume of 10000 m^3 and 8 coal miners killed. It becomes increasingly more important to enhance the accuracy of outburst prediction before uncovering coal in cross-cuts and shafts. In order to predict accurately coal and gas outbursts, we must first test gas pressure. Early on, an important factor affecting the use of predicting outbursts in uncovering coal in cross-cuts and shafts was the long time spent in testing gas pressure; 10 to 15 days were needed for each borehole, seriously delaying engineering progress. Therefore, it becomes very important for us to study a new method to test gas pressure quickly before uncovering coal in cross-cuts and shafts.

2 Factors affecting test time

Gas pressure in coal seams refers to the pressure of free gas when the absorbed gas and free gas are balanced. In testing this pressure, we usually drill a borehole in a coal seam and insert a pipe, install a pressure-meter on the outside end of the pipe and then seal the borehole. At the start, gas pressure in the borehole is quite low, causing the gas around the borehole to migrate toward it; in the end, the gas pressure in the borehole reaches a constant value which can be read from the pressure-meter. The pressure value read from the pressure-meter is nearly the same as the original gas pressure in the coal seam.

The time needed for gas pressure in borehole to increase to the original gas pressure of a coal seam is related not only to natural factors such as the original pressure itself and air permeability of the coal seam, but also to some artificial factors, such as the bore-

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hole sealing time, sealing technique and sealing quality. We cannot change the natural factors, but we can change these artificial factors. So we must study how these artificial factors affect pressure tests in order to enable the pressure test to be carried out quickly and accurately.

From analyzing the pressure test process we can see that, at the beginning when a borehole has been drilled through a coal seam, the gas pressure of the borehole is equal to or greater than the atmospheric pressure, but lower than the gas pressure of the coal seam. Over time, gas in the coal seam will migrate along fractures towards the borehole. In the area near the borehole, both the free gas and the absorbed gas flow easily towards the borehole, causing the gas pressure to decrease more quickly in the area around the borehole than in the area far from the borehole, forming a radial flow field, whose radius keeps increasing around the borehole. The longer the gas emission time, the larger the area of the flow field (Fig. 1)[1]. After the borehole has been sealed, gas will be accumulated in it, causing pressure in the gas room of the borehole gradually to increase. During this increasing process of pressure in the gas room, the gas pressure which had decreased before the borehole had been sealed in the area around the borehole, also increases, causing some free gas to become absorbed gas again. In the end, the pressure in the borehole becomes equal to that of the coal seam, far from the borehole. We can see therefore that the main factors affecting the time needed for carrying out pressure tests are borehole sealing quality, gas emission time and the volume of the gas room in the borehole.

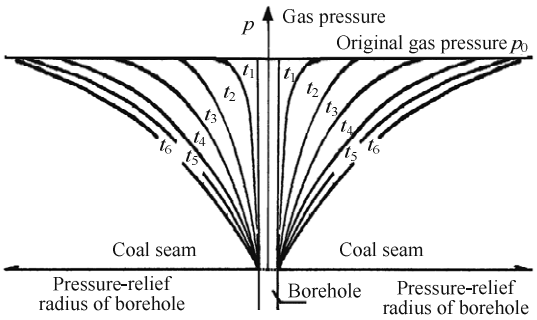

Fig. 1 Diagram of variation in gas pressure of coal seams during gas emission of borehole

The sealing quality refers to the effective interception, by sealing material, of gas in the borehole in order to ensure that the gas will not leak to the outside when the gas pressure reaches the original pressure in coal seams. Clearly, the sealing quality is vital to the gas pressure test, because any small amount of gas leakage may result in the condition that the tested pressure is not the original value of the coal seam.

The gas emission time refers to the time from the start after the borehole has been formed to the beginning after the borehole has been effectively sealed. The shorter the gas emission time, the smaller the radius of the radial flow field formed around the borehole, the smaller the gas volume needed to reach the original pressure, and the shorter the time for the pressure test. There are two factors affecting gas emission time. One is the sealing time: the earlier the sealing time, the shorter the gas emission. Another is the length of time needed for the sealing to become effective. Some sealing materials require a certain amount of time to become solidified and only then can the pressure-meter be installed. If the pressure-meter is installed before the sealing material has become solid, the increasing gas pressure will push the sealing material away from the borehole, making for a failed seal. So, the shorter the time required for sealing to become effective, the shorter the gas emission time will be.

In a borehole, the smaller the volume of the gas room (including the pipe), the more favorable it is for pressure to increase. Therefore, to decrease the diameter as much as possible is favorable for shortening the time required for the pressure test to be carried out.

In addition, for thick coal seams, the depth of the borehole is also an important factor affecting the length of time needed for the pressure test. Given the principles of pressure tests, there is an interface between the borehole and the coal body and, if the gas pressure from the interface towards the coal body remains in balance with that of the borehole, we can obtain the true value of pressure, which implies that the borehole is not necessarily required to penetrate the entire seam. On the one hand, in practical drilling, gas within a coal seam continues to be emitted and, the thicker the coal seam, the longer the drilling time and the greater the volume of gas flowing out. For some soft coal seams, which have a high risk of outbursts, a large pressure-relief area may be formed, so that the deeper the borehole in the coal seam, the larger the volume of gas will flow out and the longer the time required for gas to become balanced. On the other hand, the deeper the borehole in the coal seam, the larger the area from which gas flows out, which is favorable for the balance of gas pressure between borehole and coal seams, shortening the time needed for a pressure test. The shorter the borehole, the smaller such area from which gas is emitted and the longer the time needed for the pressure test. So, the depth of boreholes in coal seams should be determined for each practical situation.

3 Selection of sealing method

Because pressurized gas will dissipate everywhere, the sealing quality of the borehole is very important in order to test the original gas pressure accurately. Therefore, a reliable sealing method must be used in accurately testing the gas pressure before uncovering