New Technology of Directly Measuring Gas Content of Stress-Releasing and Sealed Coal Core

CHEN Xue-xi[1] , ZHOU Shi-ning[2] , QI Li-ming[3]

[1,3]*School of Safety Engineering, North China Institute of Science and Technology, Beijing, China*

[2]*School of Safety Engineering, China University of Mining and Technology, Xuzhou, China.*

Abstract: There are some problems about the technology of directly measuring gas content. These problems mainly include: the quantity of gas loss is bigger, and compensating computation is indeterminacy, and mensuration accuracy is lower. Aimed at these problems, the direct measurement gas content new technology was brought forward, and after the coal core was fetched, it will be stress-releasing and sealed. It may reduce the quantity of gas loss compensating computation, and it can drill the coal core by the tailor-made sampling implement, and it may collect the emission gas from coal core by making use of the vacuum stress-releasing chamber in the progress of boring. After the coal core was fetched, the sealing fluid that was in the sampling implement was squeezed by some outside force, and the jaws of coal core sampling implement was sealed, and it may reduce the gas loss in the process of fetching the coal core. After the coal core was taken out from the bore, the aiguille was unloaded, and the sealing lid was set. The gas desorption quantity of coal core was mensurated by the valve in the vacuum distressing chamber, and the gas loss quantity that coal core was transferred from the sampling implement to the coal sample jar was reduced. The locale contrast trial shows: the summation of coal core desorption quantity and remanet quantity mensurated by this technology is 16% and 9% higher than those of traditional drilling cuttings method and common coal core method. Therefore, the technology may be used to mensurate coal seam gas content, and its reliability and accuracy are higher.

Keywords: gas content; coal core sampling implement; vacuum stress-releasing; sealing package; accuracy

1. Introduction

Coal seam gas content is one of basic parameters about the gas prevention work, and it may be used to forecast the fatalness of outburst, compute the coal seam gas reserves and appraise the drainage performance of coal seam gas[1-5]. Presently, there are two methods about the mensuration of gas content, and they are indirect method and direct method[6-8]. In fact, the direct method was used abroad, and it has two shortages.

1) the quantity of gas loss is obtained by compensating computation, and there are a lot of methods about its computation; the rule of gas desorption has relation with the time, coal performance and the medium, and the error of gas loss quantity that is computed is bigger.

2) Ii is very difficult to ensure that the drilling cuttings are from the frontage of bore; because, in the progress of drilling, it is possible that the drill pipe shakes, and the coal that lies in the surrounding of bore was broken, and some drilling cuttings were brought, and these drilling cuttings would also flow from bore.

Aimed at the lack of direct method, a lot of upswing researches were done in home and abroad; CQCCRI fetched coal core by double deck pipe, and its power are wind power and water power, and the new fetching drilling cuttings was developed by Australia and Huainan mining group, and it may let the drilling cuttings from the frontage of bore effuse from the pipe interspac[e][2]. These research fruits are able to insure that the fetching drilling cuttings are from the frontage of bore, and but, the method that debases the quantity of gas loss needs to being more researched.

Therefore, the new technology of directly measuring gas content of stress-releasing and sealed coal core was researched in the text, and it may fetched the coal core that lies in the frontage of bore and the coal core may be wrapped by sealing fluid, and it not only ensure that the coal core is from the frontage of bore, but also debases the quantity of gas loss.

2. The technology principle of directly measuring gas content of stress-releasing and sealed coal core

The technology principle of directly measuring gas content of stress-releasing and sealed coal core is shown as followed. At first, one bore in coal seam was drilled, and then, the coal core that lies in the frontage of bore was fetched by making use of coal core sampling implement who includes the sealing fluid (when the coal core was fetched, the sealing fluid flows to the frontage of coal core sampling implement, and after the coal core was fetched, the coal core was sealed by the sealing fluid); the coal core sampling implement was pulled out, and the gas desorption of coal core takes place in the condition of nature, and the quantity of desorption is mensurated; finally, the coal core is sealed, and it will be taken

back to the lab, and the remanet gas quantity will be mensurated.

The result of directly measuring gas content of stress-releasing and sealed coal core includes the following three parts[9].

1) The quantity of gas loss before fetching coal core

It takes about 30 minutes from drilling the bore to fetching the coal core, and the gas of coal core flows to the bore in accordance with the rule of Darcy, because the gas pressure in coal core is higher than the gas pressure of bore (about 0.1MPa); therefore, before the coal core was fetched, some gases were lost, and in the here, these gases may be expressed by the Q_1.

2) The coal core gas desorption quantity in the process of fetching coal core

In the process of fetching coal core, the sealing fluid sealed the profile and frontage of coal core mainly, and the back end assumes the state of nature, and then, the gas of coal core flows from the back end to the gas storehouse under the action of the pressure grads; the gas pressure of coal core will falls, and the gas pressure in the gas storehouse will rise, and finally, they will reached some balance state.

After the coal core was fetched, the gas of storehouse was exported by making use of some apparatus, and finally, it is the coal core gas desorption quantity in the process of fetching coal core, and it may expressed the Q_2.

3) The remanet quantity of coal core

When the gas of storehouse was exhausted basically, the coal core should be taken out at once and put into the sealing jar, and it will be taken to the lab. In the lab, the coal core was grinded, and then, the gas desorption of coal core will take place in the condition of nature and high temperature, and finally, the remanet quantity of coal core is mensurated, and it may expressed the Q_3.

According to the above analysis, the gas content is the ratio of the gas summation and the fetched coal core mass, and the gas summation includes the quantity of gas loss before fetching coal core, the coal core gas desorption quantity in the process of fetching coal core and the remanet quantity of coal core.

$$x = \frac{Q_1 + Q_2 + Q_3}{G} \tag{1}$$

In the formula, x is the coal seam gas content, m^3/t; G is the fetched coal core mass, t.

To be compared with the existing direct method, the new means has two specialties: it fetches the chunk coal core, and the direct method fetches drilling cuttings of 1～3mm; it envelops the gas of coal core by making use of sealing fluid, and the gas desorption takes place at liberty in the condition of direct method. Therefore, the quantity of gas loss is smaller by new means than by direct method, and its success depends on the quantity of gas loss in some extent.

3. The quantity computation method of gas loss before fetching coal core

The fetched coal core is a cylinder approximately, and its bottom is short of a hemisphere, and predigesting the computation, assuming that there is a hemisphere in the top, it is shown as figure 1.

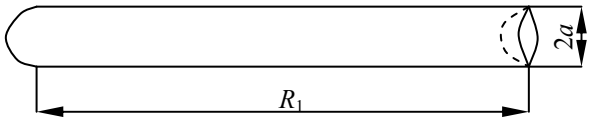

Figure 1. The sketch map of fetched coal core

The quantity of gas loss before fetching coal core is shown as followed.

In the formula, Q_1 is the quantity of gas loss, m^3; a is the radius of bore, m; R_1 is the length of coal core, m; a_1 is the radius of coal core, m; p_1 is the original coal seam gas pressure, MPa; p_0 is the pressure of atmosphere in the bore, Mpa; b is a constant, min/m; t is the time of gas fluxion, min.

$$Q_1 = 2\pi a(a - \sqrt{a^2 - a_1^2})\alpha(R_1\sqrt{p_1} - 2\frac{t}{b}\sqrt{(p_1 - p_0)} \times (\arctan\sqrt{\sqrt{1 - e^{-bR_1/t}}} - 2\sqrt{\sqrt{1 - e^{-bR_1/t}}} - \frac{1}{2}\ln\frac{1 - \sqrt{\sqrt{1 - e^{-bR_1/t}}}}{\sqrt{\sqrt{1 - e^{-bR_1/t}}} + 1})) \tag{2}$$

According to related parameters, the quantity of gas loss may be computed in the different release time and different length of coal core, and the result is shown as table 1.

Table 1. The relation of gas leak quantity, release time ,and coal core length

Release time t（min）	1	10	20	30	40
Length of coal core R_1（m）	1.0				
Q_1（10^{-3} m^3）	4.836	6.727	7.646	8.269	8.744
Raito（%）	7.5	10.5	11.9	12.9	13.6

According to the table 1, before fetching the coal core, there are some gases loss in coal core, and the quantity of gas loss is not big, and it accounts for about 10% of coal core gas content; it augments with the time of leak postponing, and the trend of augment becomes relaxation gradually.

4. Equipment of directly measuring gas content of stress-releasing and sealed coal core

4.1 collectivity design

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The new type coal core sampling implement adopts the following scheme, and it includes transmitting by single pipe, vacuum stress-releasing, cooling by wind and sealing by mucilage, and the design demand of reducing the gas leak quantity and holding the property of original coal. The coal core sampling implement is shown as figure 1, and it includes two parts of outside pipe system and inside pipe system; outside pipe system may transfer the pressure and torsional moment of pipe, and inside pipe system has property of transmitting by single pipe, vacuum stress- releasing and sealing by mucilage.

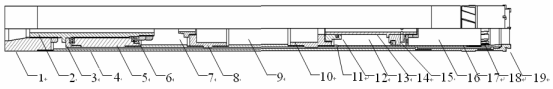

Figure 2. The fetching core implement diagram of transmitting by single pipe

1-different diameter connector; 2-body shaft of transmitting by single pipe; 3- axletree seat; 4- outside pipe;5-body of transmitting by single pipe; 6- axletree; 7-vacuum room drainage connector; 8-inside pipe connector; 9- vacuum room; 10- inside pipe connector; 11- mucilage exit; 12- vacuum sealing connector; 13-mucilage room; 14- piston pole; 15- piston; 16- coal sample room; 17- inside pipe of fetching coal core; 18-fix spring; 19-aiguille.

The coal core sampling implement of transmitting by single pipe and stress-releasing and sealed is shown as figure 3.

Figure 3. The fetching core implement of transmitting by single pipe

4.2 Working principle

Transmitting by single pipe: using the body organ of transmitting by single pipe, the inside pipe doesn't circumrotate in the process of working, and it may avoid the question that complete coal core is not fetched because of coal sample disturbance.

Cooling: there is a ring clearance between inside pipe and outside pipe, and the cooling medium reaches the aiguille via it and cools the aiguille; the temperature of coal sample is close to the original coal temperature by making use of cooling of wind and water, and the coal sample wouldn't metamorphose because of high temperature, and it resolves the problem of coal core heating; the fetched coal core is complete comparatively, and the coal sample presents block state, and it may assure the veracity of mensuration result.

Sealing and fetching coal core: the inside pipe of fetching coal core is divided into two parts of mucilage room and coal sample room by piston, and vacuum room is connected with the inside pipe of fetching coal core, and it is fenced out by the clapboard who lies in the bottom of vacuum sealing connector; when the coal sample enter into some distance of coal sample room, it will drive the piston move to the direction of mucilage room, and the piston pole cracks the clapboard, and the channel of vacuum stress-releasing is gotten through, and the gas flows from the permeability board who lies in the top of piston and piston pole inner bore to vacuum room; at the same time, the piston makes the mucilage flow from the bottom of fetching coal core pipe, and it will reach aiguille under the impulse of cooling medium pressure, and the mucilage sealing will be realized under the action of it and inside pipe, and the quantity of gas leak will fall.

5. Gas content mensuration trial in Huainan

(1) Parallel of distressing and sealed fetching coal core and drilling cuttings method

The down crossheading in the 512(5) working face was drilling in Wangfenggang mine, and the parallel trial of gas content mensuration between stress-releasing and sealed coal core and traditional drilling cuttings method has been conducted. According to locale mensuration of 2 month, a lot of paralle trial data were gained, and it is shown as table 2. in order to analyze the result comparatively, the result in table 2 is the gas content of 1000 g coal sample.

According to table 2, the summation of coal core desorption quantity and remanet quantity mensurated by distressing and sealed method is about 6564 ml averagely, and the summation by drilling cuttings method is about 5856 ml averagely, and the summation by distressing and sealed method is16% higher than those of traditional drilling cuttings method; besides, the gas content by distressing and sealed method is bigger than those of traditional drilling cuttings method.

(2) Parallel of distressing and sealed fetching coal core and Common coal core method

In the floor drainage lane of C13 coal seam -823m level Wangfenggang mine, the parallel trial of gas content mensuration between stress-releasing and sealed coal core and traditional Common coal core method has been conducted. The trail result is shown as table 3, in order to analyze the result comparatively, the result in table 3 is the gas content of 1000 g coal sample too.

Table 2. The parallel experiment result of gas content mensuration between stress-releasing and sealed coal core and traditional drilling cuttings method

Serial number	Method of fetching coal core	Q_1 (ml)	Q_2 (ml)	Q_3 (ml)	Q_2+Q_3 (ml)	Gas content (ml/g)
1	Distressing and sealed method	612①	3042	3813	6855	7.467
	Drilling cuttings method	986	2622	3287	5909	6.895
2	Distressing and sealed method	696①	3254	3572	6826	7.522
	Drilling cuttings method	1035	2805	3079	5884	6.919
3	Distressing and sealed method	834①	2978	3100	6078	6.912
	Drilling cuttings method	1136	2567	2672	5239	6.375
4	Distressing and sealed method	645①	3017	3459	6476	7.121
	Drilling cuttings method	897	2600	2981	5582	6.479
5	Distressing and sealed method	898①	2956	3632	6588	7.486
	Drilling cuttings method	1196	2548	3131	5679	6.875

Table 3. The parallel experiment result of gas content mensuration between stress-releasing and sealed coal core and traditional coal core

Serial number	Method of fetching coal core	Q_1 (ml)	Q_2 (ml)	Q_3 (ml)	Q_2+Q_3 (ml)	Gas content (ml/g)
1	Distressing and sealed method	1036	4876	5908	10784	11.82
	Common coal core method	1150	4473	5420	9893	11.04
2	Distressing and sealed method	986	4548	4896	9444	10.43
	Common coal core method	1108	4172	4491	8664	9.77
3	Distressing and sealed method	846	4122	4792	8914	9.76
	Common coal core method	960	3781	4396	8177	9.14
4	Distressing and sealed method	968	4682	4908	9590	10.56
	Common coal core method	1084	4295	4502	8798	9.88
5	Distressing and sealed method	882	4143	5665	9808	10.69
	Common coal core method	996	3800	5197	8998	9.99

According to table 3, the summation of coal core desorption quantity and remanet quantity mensurated by distressing and sealed method is 9% higher than those of traditional common coal core method; besides, the gas content by distressing and sealed method is bigger than those of traditional common coal core method.

coal core method. Therefore, the technology may be used to mensurate coal seam gas content, and its reliability and accuracy are higher.

6. Conclusion

1) There are some problems about the technology of directly measuring gas content. These problems mainly include: the quantity of gas loss is bigger, and compensating computation is indeterminacy, and mensuration accuracy is lower.

2) The new technology of directly measuring gas content of stress-releasing and sealed coal core was brought forward, and the gas loss quantity that coal core was transferred from the sampling implement to the coal sample jar was reduced by making use of this method, and it may reduce the quantity of gas loss compensating computation.

3) The locale contrast trial shows: the summation of coal core desorption quantity and remanet quantity mensurated by this technology is 16% and 9% higher than those of traditional drilling cuttings method and common

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