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New sealing material for drainage operations

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A new sealing material for the drainage operations from pulverized coal was investigated. Its microstructure and strength characteristics are determined. Evaluation of the quality of the test material for hermetic sealing of holes was verified in a coal mine. Experiments have shown that the concentration of drainage gas in the wellbore, which is sealed with sealing material from the pulverized-hole, is higher than when using an expensive cement material (82.50% vs. 69.65%).
Key words: safety; sealing materials; SEM; compressive strength; hole sealing test; gas extraction

Исследован новый уплотнительный материал из пылевидного угля для дренажных операций. Определены его микроструктура и прочностные характеристики. Оценка качества исследуемого материала для герметизации отверстий проверена на угольной шахте. Эксперименты показали, что концентрация дренажного газа в стволе скважины, которая запечатана уплотняющим материалом из пылеугольного отверстия, выше, чем при использовании дорогостоящего цементного материала (82,50% против 69,65%).

Новий ущільнювачий для дренажних операцій. *H Li, SS Guo, DS Yuan.*
Досліджено новий ущільнювачий з пилоподібного вугілля для дренажних операцій. Визначено його мікроструктуру і міцності. Оцінка якості досліджуваного матеріалу для герметизації отворів була перевірена на вугільній шахті. Експерименти показали, що концентрація дренажного газу в стовбурі свердловини, яка запечатана ущільнюючим матеріалом з пиловугільного отвору, вище, ніж при використанні дорогого цементного матеріалу (82,50% проти 69,65%).

1. Introduction

The gas drainage effect is mainly determined by the sealing process and sealing materials, which are mainly divided into four types: clay materials, cement materials, high water content materials and polymeric materials [1-4]. However, these materials have many drawbacks and depend on the weather conditions [5-7]. Therefore, the problem of developing new sealing materials is very relevant.

In order to improve the underground hole sealing effects, a new kind of sealing material for the holes based on coal with additives is proposed. This material can guarantee better effect than traditional hole sealing materials, has low cost, its application provides protection of the environment and reduced labor costs.

The aim of this article is research and analysis of the pulverized coal hole sealing materials under condition of different components; comprehensive inspection to pulverized coal

hole sealing material's actual hole sealing performance through underground hole sealing test to provide the basis to pulverized coal hole sealing material's research and application.

2. Experimental procedure

2.1 Experiment of scanning electron microscope

The SEM test unit is a combination of a packing material from pulverized coal with raw coal and a combination of expansive cement with raw coal. The compacted pulverized coal material consists of pulverized coal and a certain proportion of additives. Coal powder is a drill cuttings produced in the underground drilling of a coal mine. The additive is a special material with many excellent characteristics, developed by the author independently. Crude coal is directly obtained from the underground mine of a coal mine. The form is a conventional tube made of PVC with a diameter of 20 mm, water for the experiment is ordinary tap water.

According to the research requirements, the experiment was divided into two groups, the first group is the binding effect of coal powder sealing material and raw coal body, the experiment was divided into three levels (Table 1).

The second group is the combination of ordinary silicate expansion cement with raw coal, there is only one level in this experiment, and the specific conditions were shown in Table 2.

Before the experiment, we need to process blocks according to the experimental requirements. At first, we should put raw coal in PVC tube, and then mix the mixture according to the predetermined ratio, when the slurry Mix well, pour the slurry into a PVC pipe which have a raw coal in it, let it reaction to solidification naturally. Then place it in a standard care box and maintain 28d , after curing, remove the specimen from the curing box, use the cutting machine to process them into test block which is conform to scanning electron microscope experiment's criterion, as shown in Fig. 1.

Because there have no electrical conductivity of the coal seal material, so here we use PECS – 685. C etch coating apparatus to set conducting film on the test block. To make it surface have electrical conductivity, and then scanning the test block's surface by scanning electron microscopy. Every rest block need to be scanning of itself and the binding site with the raw coal. According to the actual observation effect, we adjust the instrument to appropriate multiple, obtain micro-structure images.

2.2 Experiment on compressive strength

Experimental study the pulverized coal hole sealing material strength characteristics on the

Fig. 1 Test block of sealing material (from left to right are group 1 experiment's level 1, level 2, level 3, group 2 experiment's level 1)

Table 1. Experiment's level division of the first group

Level	Factors		
	Water cement ratio	Pulverized coal proportion	Additive proportion
1	1:1	70%	30%
2	1:1	60%	40%
3	1:1	50%	50%

Table 2. Experiment's level division of the second group

Level	Water cement ratio	Ordinary silicate expansion cement
1	1:1	100%

Table 3. The group division of compressive strength experiment

Level	Factors		
	Water cement ratio	Pulverized coal proportion	Additive proportion
1	1:1	90%	10%
2	1:1	70%	30%
3	1:1	50%	50%
4	1:1	30%	70%

condition of different dosage of additive, so the experiment belongs to single factor and multi-level, comprehensive experimental method may be used for the experiment, the experimental group is shown in Table 3.

Use measuring cups to weigh a certain mass components accurately. Mixing coal slurry as the required water cement ratio, add quantitative additives when the slurry is stirred evenly, stir again and make it dispersed in the slurry evenly. The prepared material is injected into a plastic mold of 150 mm x 150 mm x 150 mm. After injection molds are injected into the molds, put it in hby-60z cement constant temperature and humidity standard maintenance box for maintenance, set curing temperature 35°C, curing humidity 95%. Curing 28 d and then then remove the module out of the mold, then use the cylinder sample machine and the

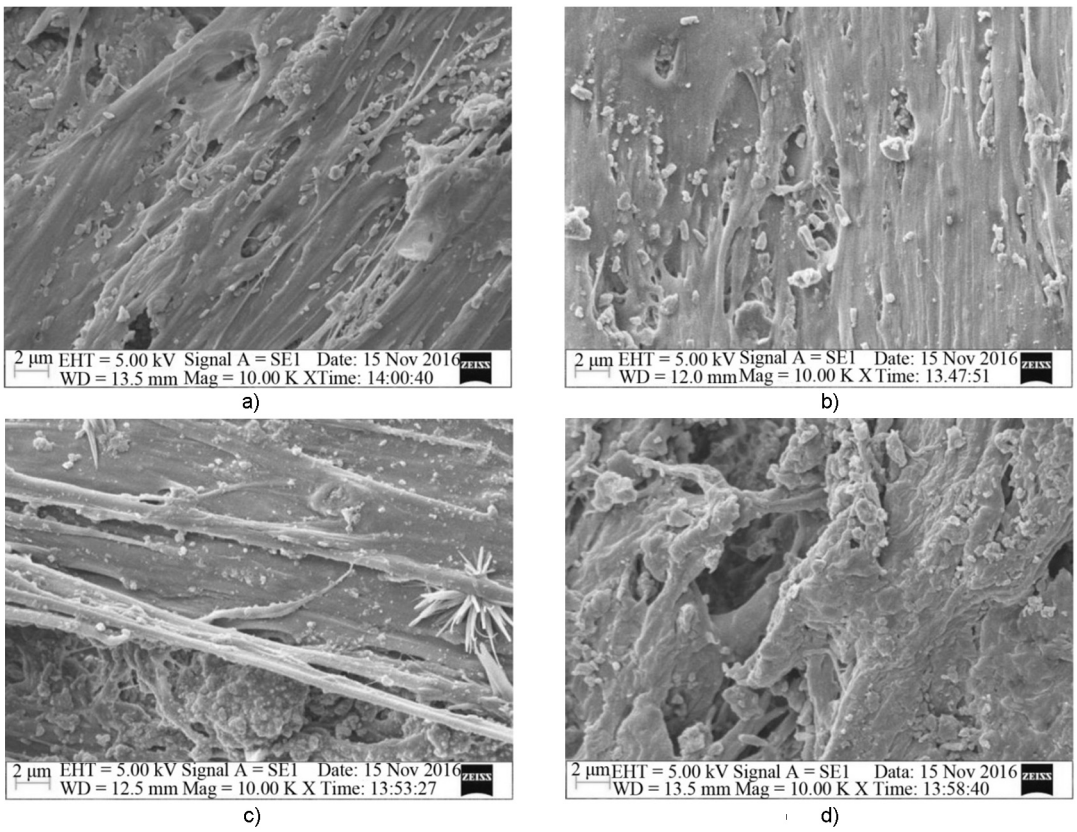

Fig. 2. Hole sealing material's micro-structure

grinding machine to process the module, processed into standard cylinders of which size are 50 x 100 mm, the specific specimen is shown in figure below..

The test pieces of the experiment were divided into four groups: A, B, C and D, with three specimens in each group. Among them, group A specimen's additive ratio is 10%, group B specimen's additive ratio is 30%, group C specimen's additive ratio is 50%, group D specimen's additive ratio is 70%. Using the American css-yaw3000 electron-hydraulic servo pressure testing machine to test each test piece's compressive strength.

3. Results and discussion

3.1. Experiment of scanning electron microscope

Using electron microscope scanning (SEM) way to make scanning and observation to the test block. Obtain the pulverized coal hole sealing materials and the ordinary Portland cement itself and combine with the raw coal face's micro-structure, the micro-structure is shown in Fig. 2.

In Fig. 2, (a), (b), (c) respectively correspond to pulverized coal sealing material's micro-structure of additive proportion are 30%, 50% and 70% of which are in the first experiment group, (4) respectively correspond to ordinary silicate expansion cement's micro-structure of which are in the second group. It is can be seen clearly in the figure, for pulverized coal hole sealing materials, along with the increase of the additive's proportion, pulverized coal hole sealing material micro-structure will the more closely, and it is can be seen that there have many holes in expansive cement's micro-structure, these holes will cause the poorer air tightness, thus influence gas drainage effect.

Using SEM technology to make scanning and observation to the binding face of pulverized coal hole sealing materials with raw coal and binding face of ordinary Portland cement with raw coal. Obtain the micro-structure characteristics of the binding face, the details are shown in Fig. 3.

In Fig. 3, (a), (b), (c) respectively correspond to the microscopic structure of coal powder sealing material and row coal's combining site of additive proportion are 30%, 50% and 70% of which are in the first experiment group, (4) respectively correspond to the microscopic structure of ordinary Portland cement and row coal's combining site of which are in the second group.

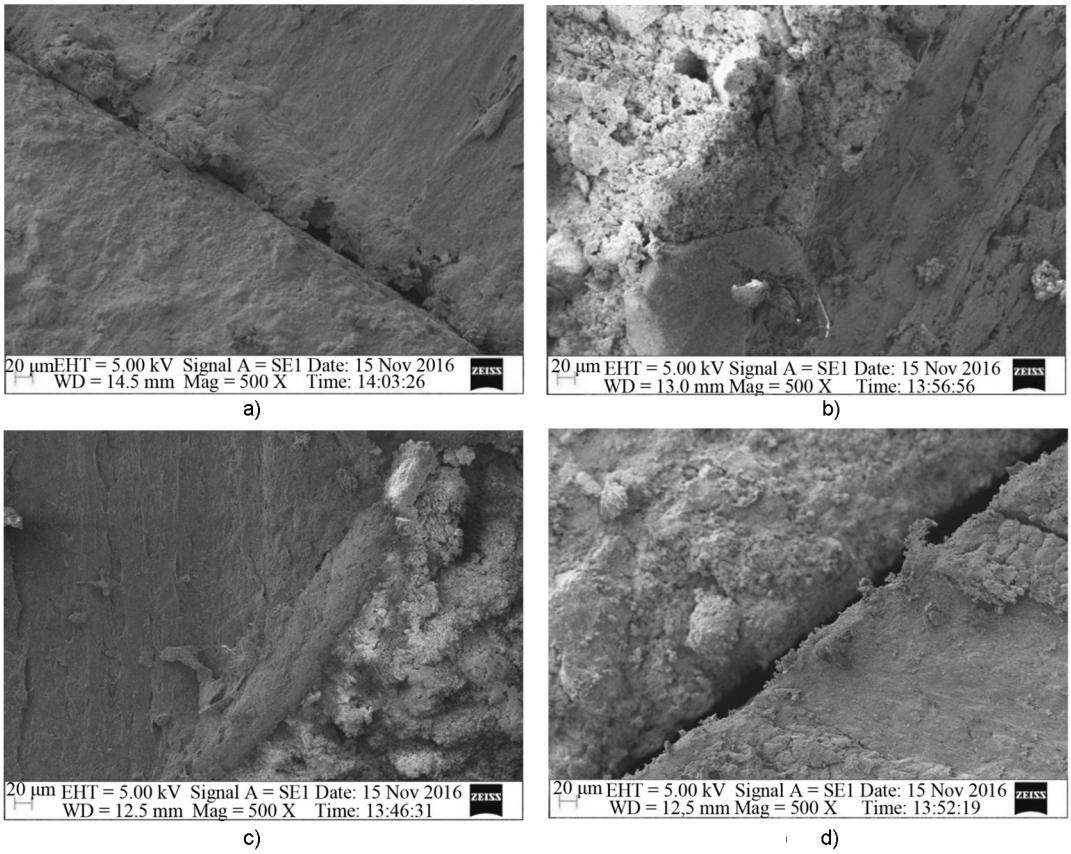

Fig. 3. The micro-structure of combination between hole sealing material and raw coal

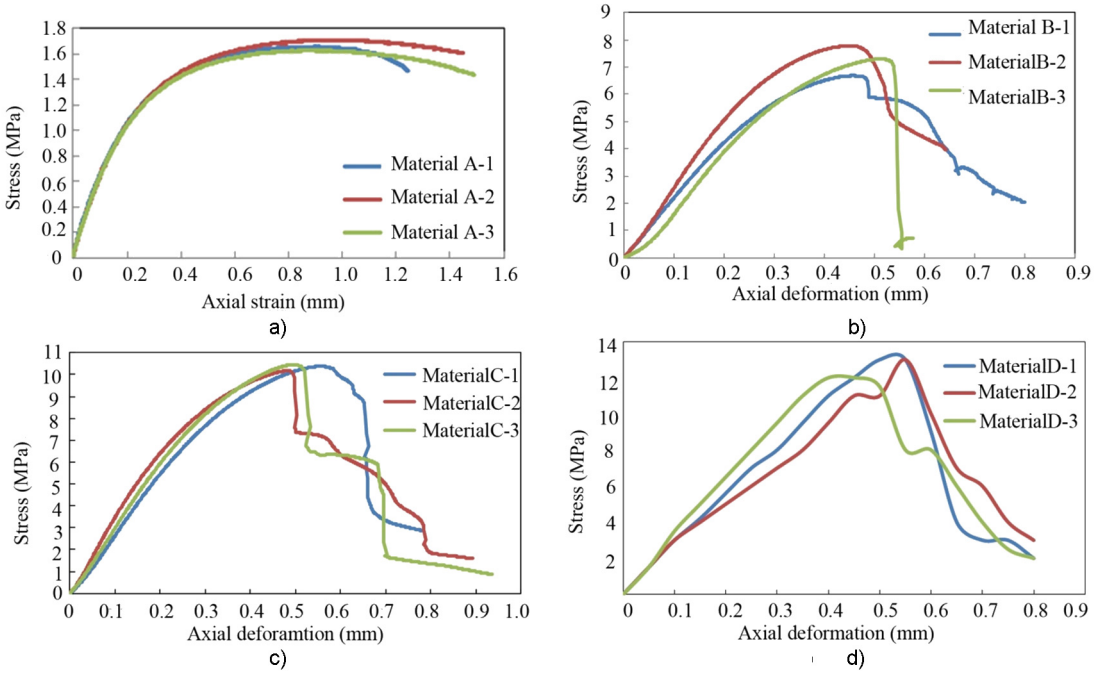

Fig. 4. The compressive strength curve of pulverized coal hole sealing material

It is can be seen in the figure, for pulverized coal hole sealing materials, along with the increase of the additive's proportion, the micro-structure of the pulverized coal hole sealing material and raw coal's joint surface become more tightly, and there are some larger cracks in the

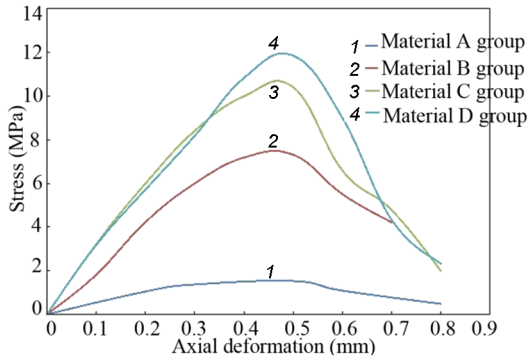

Fig. 5. The pulverized coal hole sealing material's average compressive strength curve of different additives

combination of expansive cement and raw coal face, it resulting leakage channels, which will produces gas leak phenomenon during the actual gas drainage process underground, influencing drilling plugging effect seriously, leading to poor gas drainage effect.

3.2. Experiment on compressive strength

The experimental data uni-axial compression are presented in Fig. 4.

Ingratiating each set of data, and then get each group specimens' average compressive strength data, plotting the average compressive strength curve according to the data, as is shown in Fig. 5.

In Fig. 5, material A, material B, material C and material D represent the four sets of materials of the additive volume proportion respectively are 10%, 30%, 50% and 70%. It is easy to see that the increasing of the additive's volume proportion in the coal powder sealing material the can increase the strength characteristics of hole sealing materials. Additives applied to pulverized coal hole sealing material, makes the structure of the pulverized coal hole sealing material become more closely, thus enhance the strength of the material properties, makes coal hole sealing materials can have very good supporting effect on the surrounding coal wall, guaranteeing sealing effect for a long-term.

3.3. Underground hole sealing test

To obtain the comparative characteristics of the compaction of materials from pulverized coal and ordinary portland cement, two wells were drilled.

The time of observation and recording is 1 month. Using two groups of test data, the average gas concentration for a well with a coal powder compactor, and cement cemented boreholes were calculated. The results are shown in Fig. 6.

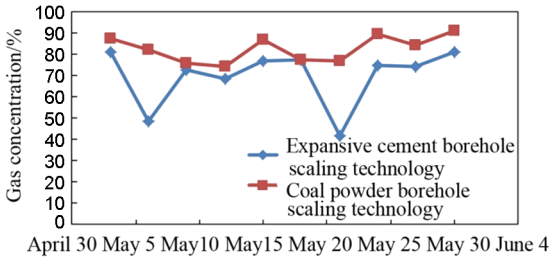

Fig. 6. The application effect's comparison of the two kinds of hole sealing materials

Fig. 6 shows that the gas concentration inside the borehole that was sealed using the coal powder borehole sealing technology was slighter higher than the gas concentration inside the borehole that was sealed using the expansive cement borehole sealing technology. Compared with the average pumping gas concentration of boreholes which were sealed with ordinary silicate expansion cement, the gas concentration increased by 12.85%. Therefore, the coal powder borehole sealing technology can achieve a good sealing effect, allowing gas extraction operations to run smoothly.

4. Conclusions

It is shown that the addition of sealing material from pulverized coal to the material from the pulverized-coal chamber of its combination with the untreated coal makes the sealing materials for the coal wells more sealed. Their microstructure becomes more dense. In contrast, ordinary silicate expansion cement seal materials and its combination with raw coal have more pore, and have lower tightness. It is shown that the addition of sealing material from pulverized coal to the material from the pulverized-coal chamber and the microstructure of its combination with the untreated coal makes the sealing materials for the coal wells more sealed. Their microstructure becomes more dense. The maximum amount of pulverized coal admixture to the untreated coal is established.

The strength characteristics of coal powder seal materials which were studied and analyzed by uni-axial compression confirmed that the increasing of the additive's volume proportion in the coal powder sealing material, the compressive strength of the coal powder sealing material test pieces will increases accordingly, in addition, it can achieve a good strength characteristic when the additive proportion reaches 30%, and can seal and support the borehole effectively.

In order to test the actual sealing performance of coal powder sealing material, a field sealing test was carried out in underground coal mine, the experimental results show that:

sealing hole with coal powder sealing material can obtain good sealing effect, compared with the average pumping gas concentration of boreholes which were sealed with expensive ordinary silicate cement, the gas concentration increased by 12.85%.

5. Acknowledgement

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