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## A Design of Intelligent Coal Seam Gas Pressure Tester

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**Abstract** In this paper, we discussed the methods and the existing problems of the direct measurement of gas pressure in the underground coal seam, it is necessary to design a kind of intelligent coal seam gas pressure tester to solve the problem of relying on the personnel to observe the pressure, to realize the automatic recording and storage of the data. Besides, it can improve the accuracy of results and lessen the labor intensity of workers, which is of great significance to achieve the digitalization and automation of gas pressure measurement.

**Keywords** Gas pressure, the sealing manometric method, digitalization

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### 1. Introduction

Coal seam gas pressure is the force acting on the coal wall produced by the free thermal movement of coal in the coal seam. It is not only one of the basic parameters to calculate the gas content by the indirect method, but also one of the important indexes to measure the coal seam outburst risk [1]. It is of great significance for the prediction of coal and gas outburst risk, and the rational development of gas control measures by accurate measurement of coal seam gas pressure, which is an important guarantee for coal mine safety production [2-3].

At present, the principle of direct measurement of underground coal seam gas is to expose the coal seam through drilling, install the measuring instrument and seal the drilling, then use the natural permeability principle of the coal seam to measure the equilibrium gas pressure at the drilling contact. Through the sealing in the coal seam after the formation of the pressure chamber where installs the pressure gauge. The coal gas around the infinite space of pressure chamber will continue to move to the pressure chamber, to ensure the flow of the surrounding flow field replenish the gas escaped in the period of the drilling process and sealing material after solidification (before the pressure gauge is installed) till the balance state. Then the pressure of the original gas pressure in the coal seam would be recorded by observing the pressure gauge manually. However, this method is time-consuming [4], and it may cause error due to manual readings, so a kind of intelligent coal seam gas pressure tester that can realize real-time observation and automatic recording is in urgent need.

### 2. Materials and Methods

At present, the direct measurement methods of downhole coal seam gas pressure in China include: filler sealing, grout sealing and bore-enveloping implement sealing manometric method.

- 1) Filler sealing manometric method: After drilling the hole, firstly rinse it with water, then install the copper tube (the diameter of about 6 ~ 8mm, the length of not less than 6m) that is the joints of the pressure gauge,



and finally use yellow mud and clay to seal. It doesn't need special equipment, the sealing length and quality are reliable, but it is time consuming and labor intensive.

2) Grout sealing manometric method: It generally selects the expansion without shrinking slurry as the sealing material that is impelled into the drilling by compressed air, which is fit for the hole angle that is greater than  $45^\circ$ , the depth of more than 15m drilling. Besides, the brass, high pressure hose or seamless steel pipe is usually used as pressure tube. The pressure measurement will be made until the cement curing to a certain strength before the installation of pressure gauge after the drilling to be closed 2 to 3 days. As the grout sealing also have a certain blocking effect on the cracks in the rock, coupled with the enough sealing length, so the manometric effect is better. However, the pressure measurement equipment can't be recycled.

3) Bore-enveloping implement sealing manometric method:

- a) Rubber ring for sealing: It is simple to operate and can be reused, while the sealing section length is small. Besides, it requires the closure of the rock must be dense and complete.
- b) Rubber ring with pressure mucus for sealing: Compared with the above one, it increases the length of the seal. Besides, the pressure mucus can penetrate into the cracks of rock (coal) body, promoting the sealing effect.
- c) Capsule - pressure mucus sealer: Due to the large elasticity of the capsule and the close contact with the hole wall, the performance of the sealing mucus is better than that of the rubber ring, which not only suits for the drilling in the rock but also the hole in hard coal seam. The device can be reused on condition that it is qualified after being carried out the pressure and leak test.

Although a number of researches have been conducted on the above-mentioned various sealing methods in China, it cannot guarantee that every time the test is successful, for that the coal seam gas pressure measurement result are related to many factors. In addition to the natural factors, such as the original gas pressure with coal, the coal permeability, the surrounding rock and so on. Meanwhile, the sealing efficiency, sealing technology and sealing quality also influence the accuracy of the results. [5]

The ultimate goal of the various test methods is to improve the accuracy of the test results via increasing the sealing effect, while it doesn't take the impact of human factors on the test results into consideration. Therefore, this paper intends to study a new type of coal seam gas pressure test equipment, which can achieve real-time observation and automatic records of coal seam gas pressure and its changes over time. [6-8]

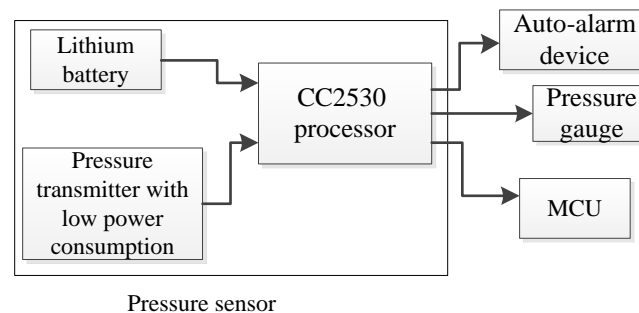


Figure 1: Composition schematic of coal seam gas pressure tester

As can be seen from Fig.1, the device is mainly composed of auto-alarm device, pressure gauge, Micro Controller Unit (MCU), pressure sensor.

The CC2530 type sensor has a function of gaining and sending pressure value analog, which means that it will collect data and send to the MCU every 5 seconds. Besides, when the battery voltage is less than 3V, the auto-alarm device will send an alarm signal.

The pressure transmitter with low power consumption can work in the 2.5V regulated power supply conditions and the normal working current is less than 1mA. Moreover, the internal Wheatstone bridge is composed of metal film resistors and adjustable potentiometer. It uses piezo resistive principle to measure coal seam gas pressure values, which means that pressure changes will bring about the Wheatstone bridge imbalance, and then output the voltage signal.



The pressure gauge selects the mechanical reader, when meets the communication unusual or the pressure meter count partial breakdown, you can still read the data to reduce the loss caused by the failure.

After drilling in the coal body, install the sensor into the pressure chamber, and then use the cement mortar and mortar baffle to fix the pressure tube. Taking the non-recyclable of the measuring equipment into account, and reduce the costs, therefore selects the CC2530 type pressure sensor equipped with lithium battery that adopts intrinsically safe design and has low energy consumption. The schematic of installation structure is shown in Fig. 2.

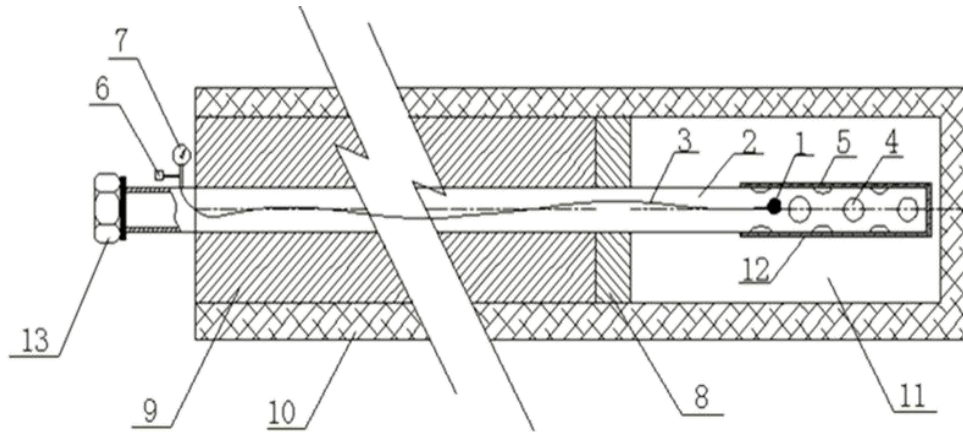


Figure 2: Schematic of the intelligent gas pressure tester installation structure

1 gas pressure sensor, 2 piezometric tube, 3 data wires, 4 casing mouth, 5 filters, 6 MCU, 7 pressure gauge with mechanical reader, 8 mortar baffle, 9 cement mortar, 10 coal mass, 11 pressure chamber, 12 fixed devices, 13 piezometric tube interfaces

Direct measurement of underground coal seam gas pressure generally includes: First of all, form a pressure chamber after sealing the drillings in the coal seam. And then install the pressure gauge, gas around the infinite space of the pressure chamber will continue to move to it, ensure that the gas escaped during the period of drilling process and the sealing material solidification is supplemented through the flow of the surrounding flow field till the final balance. Finally, we can get the real gas pressure of the coal seam.

The gas pressure sensor passes the detected pressure change value through the data wires to the MCU, which stores the data. In order to ensure the accuracy of the data, the alarm device will automatically send an alarm signal when the battery power has an under voltage. Then technical staffs get to remove the MCU, connect it to the computer, making the analysis and correction on the data by drawing the pressure curve, finally we can get the measured coal pressure.

### 3. Results and Discussion

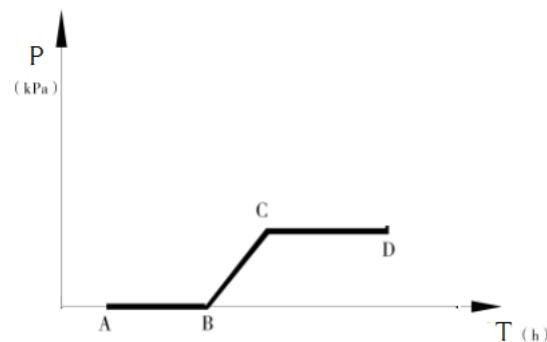


Figure 3: Theoretical curve of pressure test



The pressure tester adopts MCU to record and store data, then use the computer to draw of the theoretical curve of coal seam gas pressure. As is shown in Fig.3, the horizontal axis represents time (H), vertical pressure (kPa), ABCD line records the whole working process of the instrument. The AB section indicates the installation of the equipment and the completion of the sealing, since the pressure sensor has not yet begun to work before sealing the hole, so the AB segment is a straight line that coincides with the time axis. The sensor is activated at point B, meanwhile, gas in the drilling coal seam is constantly released, the pressure gauge also begins testing. The CD section indicates that the coal seam gas pressure is in the static equilibrium stage, after the C point, the pressure has gradually reached equilibrium until the reading is no longer fluctuated, then D point indicates the coal seam gas pressure value.

The author tested the gas pressure of the 8 # coal seam in the Wobei Mine with the design device. The main components of the coal seam are bright and mirror coal, a small amount of dark coal. The average coal seam thickness is 3.57 m. The results show that the gas pressure value (80.177 ~ 80.452 ~ 80.728 psi) of 8 # coal seam is stabilized at 80.728 psi at point D, and the gas pressure of drilling seam is about 556.7 kPa.

The instrument adopts intrinsically safe design, meanwhile, it is easy to operate. The accuracy of results will be greatly improved due to the MCU can automatically store data, which reduces the error caused by personal readings, and improves the reliability of the experiment. Compared the new observation method with the traditional one, the labor intensity was lessened, the test cost dropped down and the process flow was stabilized, thus creating favorable conditions for improving the safety level of coal production.

#### 4. Conclusion

- By introducing the direct measurement method of gas pressure in coal seam, the existing problems in the process of observing coal seam gas pressure are expounded, then propose an imagination of the intelligent gas pressure detector to solve them.
- The working principle of the intelligent gas pressure tester is introduced, through the field test and application, it can be seen from the results of the two observation methods that the structure of the instrument is simple and easy to operate, and the test cost is reduced. Besides, the safety of the workers and the accuracy of the test results are to be promoted, making the gas pressure measurement to achieve the transition to digital.

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