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**Method for enhanced fuel gas extraction by coal mine underground gas-liquid dual-phase alternating phase-driven fracturing of coal body**

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(56) Related Art  
**YANG, BAOJUN et al., 'Study and application of the compound fracturing technique', Shiyou-zuancai-gongyi, 1998, Vol 20 No. 1, ISSN 1000-7393, pages 69-73**  
**CN 102155254 A**

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(54) Title: METHOD FOR ENHANCED FUEL GAS EXTRACTION BY COAL MINE UNDERGROUND GAS-LIQUID DUAL-PHASE ALTERNATING PHASE-DRIVEN FRACTURING OF COAL BODY

(54) 发明名称: 煤矿井下气液两相交替相驱压裂煤体强化瓦斯抽采方法

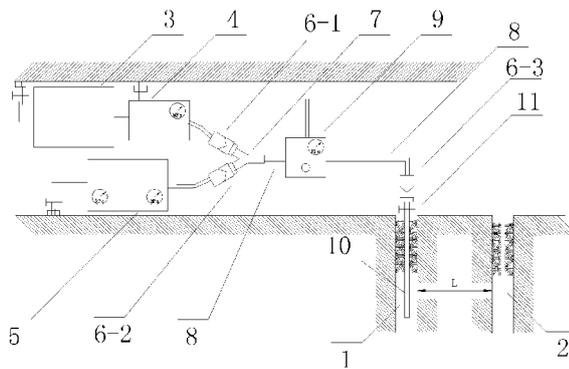


图1 / Fig. 1

(57) Abstract: A method for enhanced gas extraction by coal mine underground gas-liquid dual-phase alternating phase-driven fracturing of a coal body. Constructed in a present coal seam or a permeable stratum are a fracturing borehole and a water guiding hole, where both boreholes are sealed to withstand high pressures. Fracturing equipment is connected, pressurized water of no more than 3 MPa is injected into the fracturing borehole, and, a water pump is shut off after 10 minutes of hydraulic fracturing of the fracturing borehole, thus stopping the hydraulic fracturing. An air pressure booster is turned on for gas-phase fracturing of the fracturing borehole, and, when the pressure reaches 3 MPa, the air pressure booster is turned off, thus stopping the gas-phase fracturing. This is repeated for multiple times, when water flows out of the water guiding hole distanced from a side of the fracturing borehole, the hydraulic fracturing is stopped, while the gas-phase fracturing is continued, and, when water ceases to flow out of the water guiding hole or when a gas erupts therefrom, the gas-phase fracturing is stopped. A fuel gas extraction pipe network is connected to the fracturing borehole and the water guiding hole for fuel gas extraction. The method effectively solves the problem of fuel gas release and analysis being impeded by residual water when only hydraulic fracturing is used, thus allowing cracks within a coal body to be fully developed to an improved degree, and enhancing coal seam air permeability and fuel gas extraction effects.

(57) 摘要:

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WO 2015/054984 A1



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AZ, BY, KG, KZ, RU, TJ, TM), 欧洲 (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, KM, ML, MR, NE, SN, TD, TG)。

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**本国际公布:**

— 包括国际检索报告(条约第 21 条(3))。

一种煤矿井下气液两相交替相驱压裂煤体强化瓦斯抽采方法, 在本煤层或穿层中施工压裂钻孔、导水孔, 对两个钻孔进行耐高压封孔; 连接压裂设备, 以不超过 3MPa 的压力水注入压裂钻孔, 对压裂钻孔实施水力压裂 10min 后关闭水泵, 停止水力压裂; 开启气体增压器对压裂钻孔进行气相压裂, 压力达到 3MPa 时, 关闭气体增压器, 停止气相压裂; 如此重复多次, 当距离压裂钻孔一侧的导水孔出现水流出时, 停止水力压裂, 继续气相压裂, 当导水孔水流停止, 或有气体涌出时, 结束气相压裂; 对压裂钻孔和导水孔联入瓦斯抽采管网, 进行瓦斯抽采。该方法有效解决了单一水力压裂后水分残留阻碍瓦斯释放和解析的问题, 使得煤体内部裂隙发育更为充分, 提高了煤层透气性和瓦斯抽采效果。

Method for Enhanced Fuel Gas Extraction by Coal Mine Underground Gas-Liquid  
Dual-Phase Alternating Phase-Driven Fracturing of Coal Body

### Field of the Invention

The present invention relates to a method for enhancing gas extraction by underground gas-liquid dual-phase alternating phase-driven fracturing of a coal body, belongs to the field of gas control in underground areas in coal mine, and is especially applicable to pressure relief and permeability enhancement of underground coal seam with high gas concentration and low air permeability in coal mine.

### Background Art

Gas in the coal seam in China has characteristics including microporosity, low permeability and high absorptivity, and 80% or more coal seams in China are coal seams with high gas concentration and low air permeability. The exploitation of coal seams with high gas concentration and low air permeability is often accompanied by the eruption of a great deal of gases. Especially, as the coal production becomes more efficient and intensive, and the mining depth increases, the erupted amount of gas becomes more and more, and the risk of gas explosion and gas outburst becomes higher and higher. A key measure for solving the gas problem in the mining of coal seam with high gas concentration and low air permeability is gas extraction from the coal seam in advance. Conventional gas extraction methods usually have a small effective coverage, involve high workload of boring at the working face, have low extraction efficiency, and can not attain an ideal effect for coal seam with high gas concentration and low air permeability. To reach the standard for gas extraction and eliminate gas disasters in coal seam, permeability improving measures must be taken, and the effective coverage per borehole must be enlarged, so as to improve the gas extraction effect. At present, commonly used pressure relief and permeability enhancement measures for coal seam with high gas concentration and low air permeability involve loosening the original coal body artificially in advance to enhance the air permeability of the coal seam, mainly utilizing deep-hole loose blasting technique, water-jet cutting technique, hydraulic flushing technique, and underground coal seam hydraulic fracturing technique, etc. Deep-hole loose blasting technique, water-jet cutting technique, and hydraulic flushing technique have drawbacks including small effective coverage of borehole, high workload, complex construction process, and low extraction efficiency, etc.

As one of the major oil yield increasing measures, the hydraulic fracturing technique has been widely applied in the modern petroleum industry, and has attained some effects in the underground application in coal mine. As the field of application is expanded, the coal seam occurrence conditions become complex, and coal seam with low air permeability increases, the hydraulic fracturing technique has encountered its limitations, mainly represented in: after high pressure water enters into the coal body in a loose coal seam, it is difficult to discharge the water under the capillary action of the coal body; consequently, the gas erupting channels are blocked, and the effect for enhancing gas extraction by the coal body permeability improvement of hydraulic fracturing is weakened.

At present, the research and application of underground gas fracturing in coal mine mainly focus on high-energy gas fracturing (CO<sub>2</sub>, N<sub>2</sub>, etc.), which has attained some

2014336858 28 Apr 2017

effects for permeability improvement for coal body. However, there are difficulties in the preparation and transmission of high-energy gas and the fracturing control, hampering the wide application of high-energy gas fracturing.

Borrowing from the ideal of high-energy gas fracturing, using the air pressure provided by an underground compressed air system, and utilizing an air pressure booster in combination with the hydraulic fracturing technique, the present invention puts forth a technique for enhancing gas extraction by underground gas-liquid dual-phase alternating phase-driven fracturing of a coal body in a coal mine.

### Summary of the Invention

In view of the drawbacks in the hydraulic fracturing technique applied for loose coal seam with high gas concentration and low air permeability in the prior art, there is provided a method for enhancing gas extraction by underground gas-liquid dual-phase alternating phase-driven fracturing of a coal body in a coal mine, which employs a gas-liquid dual-phase alternating phase-driven fracturing technique to improve the air permeability of the coal seam and thereby enhancing the gas extraction effect.

The method for enhancing gas extraction by underground gas-liquid dual-phase alternating phase-driven fracturing of a coal body in a coal mine put forth in an aspect of the present invention comprises the following steps:

- a. constructing a borehole as a fracturing borehole in a coal seam or a permeable stratum, constructing another borehole having the same parameters as a water guiding hole at a distance  $L=2-4\text{m}$  from a side of the fracturing borehole, installing a fracturing pipeline with conventional techniques, and sealing both boreholes to withstand high pressures;
- b. connecting fracturing equipment to a mouth of the fracturing borehole, the fracturing equipment comprises a water supply apparatus composed of an auto-control water tank and a water pump, and an air pressure booster, a water discharge pipe of the water supply apparatus is connected with an air discharge pipe of the air pressure booster via a Y-tee joint, an outlet of the Y-tee joint is connected to the fracturing pipeline via a high-pressure rubber hose, the water discharge pipe of the water supply apparatus, the air discharge pipe of the air pressure booster, and the inlet pipe of the fracturing pipeline are provided with a check valve respectively, and the high-pressure rubber hose is provided with an overflow valve;
- c. adjusting an overflow of the overflow valve, starting the water pump, and injecting pressurized water at pressure not higher than 3 MPa into the fracturing borehole via the fracturing pipeline for hydraulic fracturing of fracturing borehole, and, shutting off the water pump after 10 minutes of hydraulic fracturing of the fracturing borehole, thus stopping the hydraulic fracturing;
- d. turning on the air pressure booster for gas-phase fracturing of the fracturing borehole, and turning off the air pressure booster when the pressure reaches 3 MPa, thus stopping the gas-phase fracturing;
- e. repeating the steps c and d for multiple times, and increasing the water pressure and air pressure by 2-3 MPa in each time, stopping hydraulic fracturing when water flows out of the water guiding hole distanced from the side of the fracturing borehole but continuing the gas-phase fracturing, and, stopping the gas-phase

fracturing when the water flow from the water guiding hole ceases or when gas erupts therefrom;

- f. closing a valve on the fracturing pipeline, removing the fracturing equipment, and connecting the fracturing borehole and the water guiding hole into a gas extraction pipeline network for gas extraction.

The method put forth in an embodiment of the present invention employs water-gas two-phase alternating phase-driven fracturing of a coal body to promote the development, extension, and inter-connection of fractures in the coal body, utilizes hydraulic fracturing to expel the gas, and then uses gas-phase fracturing to expel the water; thus, the method may effectively solve the problem of gas release and analysis impeded by residual water when hydraulic fracturing is solely used, and may thereby improve the gas extraction effect. In addition, the gas-liquid dual-phase alternating phase-driven fracturing technique may take full advantage of the two phases, and the fracturing pressure may be increased step by step; thus, the fractures in the coal body may develop more fully, and the permeability improvement effect for the coal body may be greatly improved. The method may be simple, easy to operate, and may have extensive practicability in the field of application.

### Description of the Drawings

An embodiment will now be described by way of example only with reference to the accompanying non-limiting Figure in which:

Fig. 1 is a layout diagram of the method for enhancing gas extraction by underground gas-liquid dual-phase alternating phase-driven fracturing of a coal body in a coal mine put forth in the present invention.

In the figure: 1 - fracturing borehole; 2 - water guiding hole; 3 - auto-control water tank; 4 - water pump; 5 - air pressure booster; 6-1 - check valve I; 6-2 - check valve II; 6-3 - check valve III; 7 - Y-tee joint; 8 - high-pressure rubber hose; 9 - overflow valve; 10 - fracturing pipeline; 11 - valve.

### Detailed Description of the Embodiments

Hereunder the present invention will be further detailed in an embodiment, with reference to the accompanying drawings.

The method for enhancing gas extraction by underground gas-liquid dual-phase alternating phase-driven fracturing of coal body in coal mine put forth in an embodiment of the present invention is as follows:

- a. a borehole is constructed as a fracturing borehole 1 in the present coal seam or a permeable stratum, another borehole having the same parameters is constructed as a water guiding hole 2 at a distance  $L=2-4\text{m}$  from a side of the fracturing borehole 1, a fracturing pipeline 10 is installed with conventional techniques, and both boreholes are sealed to withstand high pressures;
- b. fracturing equipment is connected to the mouth of the fracturing borehole 1 and the performance of the hydraulic fracturing equipment and gas fracturing equipment is checked and tested, the fracturing equipment comprises a water supply apparatus composed of an auto-control water tank 3 and a water pump 4, and an air pressure booster 5, the water discharge pipe of the water supply apparatus is connected with the air discharge pipe of the air pressure booster 5 via

2014336858 28 Apr 2017

- a Y-tee joint 7, the outlet of the Y-tee joint 7 is connected to a fracturing pipeline 10 via a high-pressure rubber 8, the water discharge pipe of the water supply apparatus is provided with a check valve I 6-1, the air discharge pipe of the air pressure booster 5 is provided with a check valve II 6-2, and the inlet pipe of the fracturing pipeline 10 is provided with a check valve III 6-3, and the high-pressure rubber 8 via which the Y-tee joint 7 is connected to the fracturing pipeline 10 is provided with an overflow valve 9;
- c. the overflow discharge of the overflow valve 9 is adjusted, the water pump 4 is started, and pressurized water is injected at pressure not higher than 3 MPa into the fracturing borehole 1 via the check valve 6-1, the Y-tee joint 7, the high-pressure rubber 8, and the fracturing pipeline 10 sequentially for hydraulic fracturing, and, the water pump 4 is shut off after 10 minutes of hydraulic fracturing of the fracturing borehole 1, thus the hydraulic fracturing is stopped;
  - d. the air pressure booster 5 is turned on for gas-phase fracturing of the fracturing borehole 1, and the pressure is adjusted by means of the overflow valve 9; the air pressure booster 5 is turned off when the pressure reaches 3 MPa, thus the gas-phase fracturing is stopped;
  - e. the steps c and d are repeated for multiple times, and the water pressure and the air pressure are increased by 2-3 MPa in each time; the hydraulic fracturing is stopped when water flows out of the water guiding hole 2 distanced from the side of the fracturing borehole 1 but the gas-phase fracturing is continued, and the gas-phase fracturing is stopped when the water flow from the water guiding hole 2 ceases or when gas erupts therefrom; for example, after 10 minutes hydraulic fracturing of the fracturing borehole at 3MPa low pressure, the fracturing is switched to gas-phase fracturing; when the gas-phase pressure reaches the maximum pressure of the hydraulic fracturing, the fracturing is switched to hydraulic fracturing, and the water pressure is increased to 6 MPa; after 10 minutes hydraulic fracturing, the fracturing is switched to gas-phase fracturing; when the gas-phase pressure reaches to the maximum pressure of the hydraulic fracturing, the fracturing is switched to hydraulic fracturing, and the water pressure is increased to 9 MPa; after 10minutes hydraulic fracturing, the fracturing is switched to gas-phase fracturing; and, when the gas-phase pressure reaches to the maximum pressure of the hydraulic fracturing, the fracturing is switched to hydraulic fracturing. The hydraulic fracturing is stopped when water flows out of the water guiding hole 2, and the fracturing is switched to gas-phase fracturing; the fracturing work is stopped when the water flow from the water guiding hole ceases.
  - f. the valve 11 on the fracturing pipeline 10 is closed, the fracturing equipment is removed, and the fracturing borehole 1 and the water guiding hole 2 are connected into a gas extraction pipeline network for gas extraction.

It is to be understood that, if any prior art publication is referred to herein, such reference does not constitute an admission that the publication forms a part of the common general knowledge in the art, in Australia or any other country.

In the claims which follow and in the preceding description of the invention, except where the context requires otherwise due to express language or necessary implication,

the word “comprise” or variations such as “comprises” or “comprising” is used in an inclusive sense, i.e. to specify the presence of the stated features but not to preclude the presence or addition of further features in various embodiments of the invention.

2014336858 28 Apr 2017

2014336858 28 Apr 2017

## Claims

1. A method for enhancing gas extraction by underground gas-liquid dual-phase alternating phase-driven fracturing of a coal body in a coal mine comprises the following steps:
  - a. constructing a borehole as a fracturing borehole in a coal seam or a permeable stratum, constructing another borehole having the same parameters as a water guiding hole at a distance  $L=2-4\text{m}$  from a side of the fracturing borehole, installing a fracturing pipeline with conventional techniques, and sealing both boreholes to withstand high pressures;
  - b. connecting fracturing equipment to a mouth of the fracturing borehole, the fracturing equipment comprises a water supply apparatus composed of an auto-control water tank and a water pump, and an air pressure booster, a water discharge pipe of the water supply apparatus is connected with an air discharge pipe of the air pressure booster via a Y-tee joint, an outlet of the Y-tee joint is connected to the fracturing pipeline via a high-pressure rubber, the water discharge pipe of the water supply apparatus, the air discharge pipe of the air pressure booster, and an inlet pipe of the fracturing pipeline are provided with a check valve respectively, and the high-pressure rubber is provided with an overflow valve;
  - c. adjusting an overflow discharge of the overflow valve, starting the water pump, and injecting pressurized water at pressure not higher than 3 MPa into the fracturing borehole via the fracturing pipeline for hydraulic fracturing, and shutting off the water pump after 10 minutes of hydraulic fracturing of the fracturing borehole, thus stopping the hydraulic fracturing;
  - d. turning on the air pressure booster for gas-phase fracturing of the fracturing borehole, and turning off the air pressure booster when the pressure reaches 3 MPa, thus stopping the gas-phase fracturing;
  - e. repeating the steps c and d for multiple times, and increasing the water pressure and the air pressure by 2-3 MPa in each time; stopping the hydraulic fracturing when water flows out of the water guiding hole distanced from the side of the fracturing borehole and continuing the gas-phase fracturing, and stopping the gas-phase fracturing when the water flow from the water guiding hole ceases or when gas erupts therefrom;
  - f. closing a valve on the fracturing pipeline, removing the fracturing equipment, and connecting the fracturing borehole and the water guiding hole into a gas extraction pipeline network for gas extraction.

Drawing of Abstract

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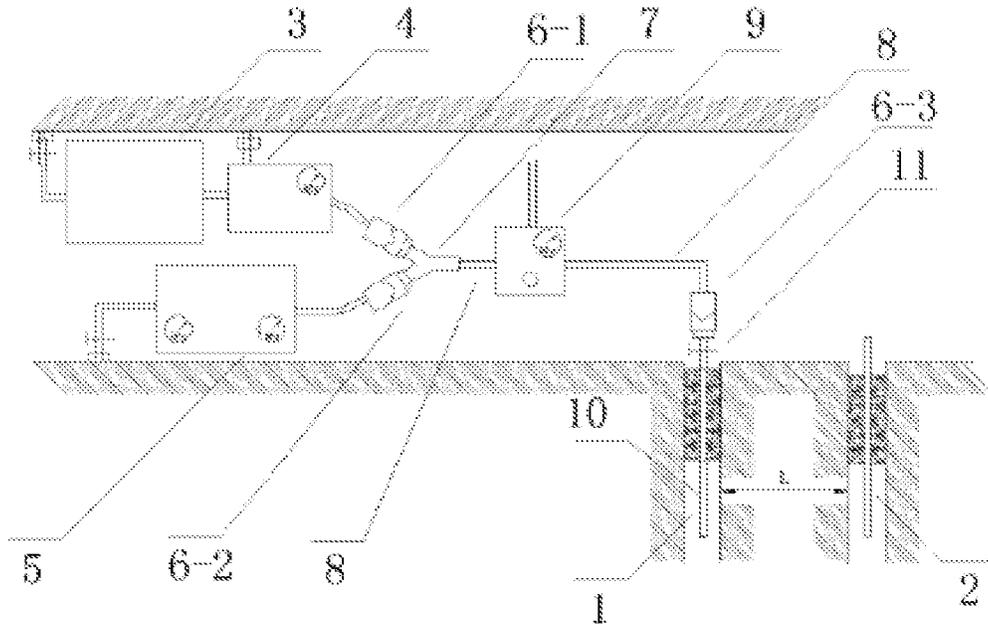


Fig. 1

Drawings of Description

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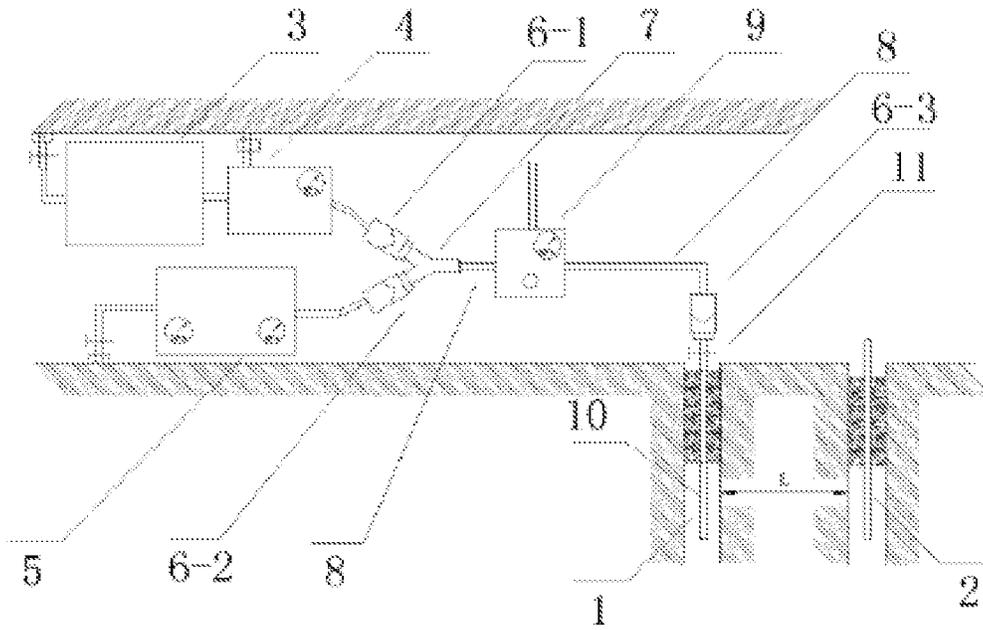


Fig. 1