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(54) UNDERGROUND GASIFICATION IGNITION METHOD

(57) An underground gasification ignition method comprises the following steps: making a directional drilling and a vertical well to construct an underground gasification furnace; using a cold fracturing method to pre-penetrate a coal seam; and igniting in the vertical well at an end of the directional drilling.

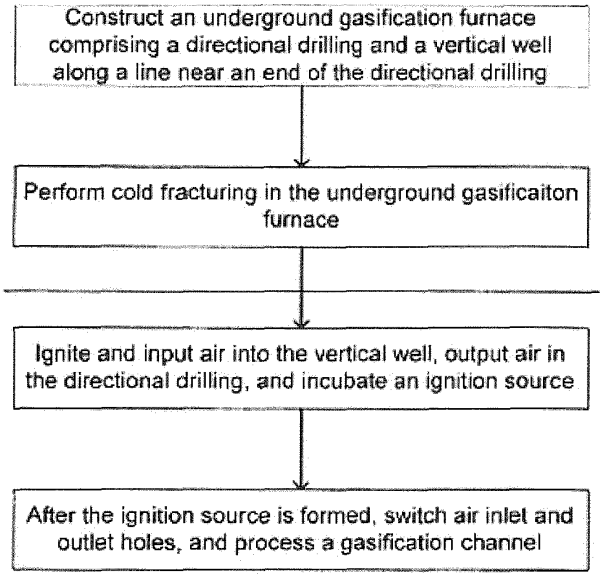

Fig. 1

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Description

Technical field

[0001] The present invention relates to a method of underground gasification ignition, applicable in fields such as underground coal gasification.

Background

[0002] The underground coal gasification is a process in which the underground coal is transferred in *situ* into combustible gas through thermal chemistry reaction. As a clean coal technology, underground coal gasification has obvious technological advantages in mining low grade coal seam, deep coal seam, thin coal seam and three under- coals (under waters, buildings or roads), thus being particularly suitable for the energy resource situation of amplitude of coal, short of oil and deficiency of gas. The technology of underground coal gasification has the economical and social benefits of small investment, short construction period and friendly circumstance, thus it has received highly attention in the international coal industry. In recent few years, as the energy situation becomes more and more stressful, science research colleges and institutes and related enterprises have made much effort on development of underground coal gasification technology, thus it has a fast development.

[0003] In the application of underground coal gasification technology, ignition in the gasification furnace and penetration and processing of a channel are very important procedures. In the current underground gasification process, channel processing often employs air firepower percolation method, hydraulic fracturing method and electrical penetration method, of which the penetration speeds are comparatively slow.

[0004] The existing underground gasification ignition method mainly followed a certain order. Firstly, a vertical well should be created, and then light a fire in the vertical well. After the fire zone was established in the vertical well bottom, the directional drillings were created. Because of the established fire zone, the directional drillings were actually processed in hot state. And after that, the channel was penetrated through the fire. Since that only vertical wells were processed when igniting, so the penetration speeds between the vertical wells were slow, and more time should be used to penetrate the wells. It means that flame moving slowly would result in low efficiency.

SUMMARY OF THE INVENTION

[0005] Against the shortcomings of the prior art, the present invention aims to provide a method of underground coal gasification ignition, in particular relates to a method of underground gasification ignition comprising the following steps:

(1) creating a directional drilling and vertical well(s) to construct an underground gasification furnace;

(2) pre-penetrating the coal seam in the method of cold fracturing;

(3) igniting in the vertical well at the end of the directional drilling. In the present invention, firstly the directional drilling and vertical well are created to construct an underground gasification furnace. Then the coal seam in the gasification furnace is fractured in cold the status and ignition is made in the vertical well at the end of the directional drilling. This method has the advantages of high ignition efficiency and fast penetrating speed.

[0006] The following is described as the preferred technical solutions of the present invention, but not as the restriction for the technical solutions provided by the present invention. With the following technical solutions, the technical goal and beneficial effect of the present invention can be achieved in a better way.

[0007] Optionally, on the basis of the technical solutions provided by the present invention, step (4) is conducted after the step (3), wherein after ignition source is formed, gas inlet hole and gas outlet hole are switched and the gasification channel is processed with firepower.

[0008] Optionally, on the basis of the technical solutions provided by the present invention, in the step (4) gas inlet hole and gas outlet hole are switched to the status that gas is discharged through the ignition vertical well.

[0009] Optionally, on the basis of the technical solutions provided by the present invention, in the step (4) the ignition source is considered to be formed when the coal-burning volume is $\geq$0.5 cubic meters.

[0010] Preferably, on the basis of the technical solutions provided by the present invention, the number of the vertical well is 1.

[0011] In the step (3), ignition is made in the vertical well at the end of the directional drilling and gas is discharged through the directional drilling. Preferably, on the basis of the technical solutions provided by the present invention, the number of the vertical wells is at least 2.

[0012] In the step (3), ignition is made in one of the vertical wells at the end of the directional drilling, and gas is discharged through at least one of the other vertical wells and pressure maintenance is made for the directional drilling at the same time. Preferably, on the basis of the technical solutions provided by the present invention, the pressure maintenance in step (3) is maintaining pressure within 0.3-1.0MPa.

[0013] Preferably, on the basis of the technical solutions provided by the present invention, the coal is brown coal and the vertical distance between the vertical well and the directional drilling channel is 2-10 meters.

[0014] Preferably, on the basis of the technical solu-

tions provided by the present invention, the coal is bituminous coal and the vertical distance from the vertical well to the directional drilling channel is 1-5 meters.

[0015] Preferably, on the basis of the technical solutions provided by the present invention, the gasification agent used for ignition is oxygen-containing gas and its oxygen concentration is ≥ 21%.

[0016] Compared with the prior art, the present invention has the following beneficial effect: in the present invention, directional drilling and vertical well are firstly created to construct an underground gasification furnace; the coal seam is pre-penetrated in the manner of cold fracturing; ignition is made in the vertical well at the end of the directional drilling. The method of the present invention has advantages of high ignition efficiency and fast penetrating speed.

Brief Description Of Drawings

[0017]

Fig. 1 shows the process flow chart of the ignition method of Example 1,

Fig. 2 shows the side view of the ignition process of Example 1,

Fig. 3 shows the vertical view of the ignition and penetration process of Example 1,

Fig. 4 shows the side view of the ignition process of Example 2,

Fig. 5 shows the vertical view of the ignition and penetration process of Example 2,

Fig. 6 shows the process flow chart of the ignition method of Example 3,

Fig. 7 shows the side view of the ignition process of Example 3,

Fig. 8 shows the vertical view of the ignition and penetration process of Example 3,

Fig. 9 shows the process flow chart of the ignition method of Example 4,

Fig. 10 shows the side view of the ignition process of Example 4, and

Fig. 11 shows the vertical view of the ignition and penetration process of Example 4.

Detailed Embodiments

[0018] For better illustrating the present invention and understanding of the technical solutions of the present invention, the typical but non-limiting embodiments of the present invention are described in the following:

In a typical embodiment of the present invention, an underground gasification ignition method comprises the following steps:

(1) creating a directional drilling and vertical well(s) to construct an underground gasification furnace;

(2) pre-penetrating the coal seam in the manner of cold fracturing;

(3) igniting in the vertical well at the end of the directional drilling. In the present invention, firstly directional drilling and vertical well are created to construct the underground gasification furnace; the coal seam is pre-penetrated in the manner of cold fracturing; ignition is made in the vertical well at the end of the directional drilling. In the present invention, firstly a gasification furnace composed of directional drilling and vertical well is constructed and ignition in vertical well is made after cold fracturing. When first creating directional drilling then conducting the fracturing, the fracturing efficiency is improved because a horizontal channel has been formed and penetration is speeded up after the ignition of the fractured channel; the ignition efficiency is improved because the fire work face movement is faster; and it is beneficial to the future operation of the gasification furnaces composed of directional drillings, because the current industrial gasification furnaces are usually composed of directional drillings .

[0019] Moreover, the present invention also overcomes the disadvantage of the prior art than burning area is firstly constructed in the bottom of the vertical well and then the directional drilling is processed at high temperature, thus the holing through process is greatly affected by the processing of directional drilling.

[0020] According to the present invention, the step (4) is conducted after the step (3), wherein after the ignition source is formed, gas inlet hole and gas outlet hole are switched and the gasification channel is processed with firepower. According to the present invention, in the step (4), the gas inlet hole and gas outlet hole are switched to the status that gas is discharged through the vertical well.

[0021] According to the present invention, in the step (4), the ignition source is considered to be formed when the coal-burning volume is ≥0.5 cubic meter.

[0022] The step (4) of the present invention further comprises a reliable control method on the basis of previous steps, wherein whether ignition source has been formed is determined by coal-burning volume at the coal

gas outlet hole, thus gas inlet hole can be switched in time, preventing from the collapse of top plate of the coal seam induced by partial channel being too wide.

[0023] According to the present invention, when the number of the vertical well is 1, in the step (3) ignition is made in the vertical well and gas is discharged through directional drilling. When the coal-burning volume is ≥ 0.5 cubic meter, ignition source is considered to be formed, then the gas outlet hole and gas inlet hole are switched to the status that gas is introduced through the directional drilling and discharged through the vertical well.

[0024] According to the present invention, when the number of the vertical wells is at least 2, in the step (3) ignition is made in one of the vertical wells at the end of the directional drilling, gas is discharged in at least one of the other vertical wells and pressure maintenance is made for the directional drilling at the same time.

[0025] When the number of the vertical wells is 2, in the step (3) ignition is made in one of the vertical wells and gas is discharged in the other vertical well. When the coal-burning volume is ≥ 0.5 cubic meter, the ignition source is considered to be formed. Then the gas outlet hole and gas inlet hole are switched according to the position of the ignition hole to the status that gas is introduced through directional drilling or the previous gas outlet vertical well, and gas is discharged through the ignition vertical well, all of which aim to process the gasification channel with firepower so as to penetrate the gasification channel.

[0026] When the number of the vertical wells is at least 3, in the step (3) firstly any one of the vertical wells is selected for ignition, and gas is discharged through at least one of the other vertical wells. When the coal-burning volume is ≥ 0.5 cubic meter, the ignition source is considered to be formed, then the gas outlet hole and gas inlet hole are switched according to the position of the ignition hole to the status that gas is introduced through the directional drilling, an auxiliary well or the previous gas outlet well, and gas is discharged through the ignition vertical well, all of which aim to process gasification channel with firepower so as to penetrate the gasification channel. The auxiliary wells are the vertical wells other than the ignition vertical well and the previous gas outlet well in the step (3).

[0027] In the step (3) of the present invention, pressure maintenance is made for directional drilling in the process of vertical well ignition and penetration, in order to prevent from the occlusion induced by late use after the directional drilling is finished and also to effectively prevent from the entry of underground water.

[0028] The number of the vertical wells is at least one, such as 1, 2, 3, 4, 5, 6, 7, etc.

[0029] The aperture diameter of the vertical well is 200-400mm, such as 220mm, 240mm, 260mm, 280mm, 300mm, 320mm, 340mm, 360mm or 380mm.

[0030] The distance from the bottom of casing tube of the vertical well to the bottom plate of the coal seam is 1-2 meters.

[0031] The channel of the directional drilling is an unsupported channel or a supported channel with sieve-tube.

[0032] The length of the directional drilling channel is 70-150 meters, such as 80 meters, 90 meters, 100 meters, 110 meters, 120 meters, 130 meters, or 140 meters.

[0033] The aperture diameter of the directional drilling is 100-250mm, such as 110mm, 120mm, 140mm, 160mm, 180mm, 200mm, 220mm, 240mm or 245mm.

[0034] In the present invention, the vertical well is not directly connected with the directional drilling. When the coal is brown coal, the vertical distance between the vertical well and the directional drilling channel is 2-10 meters, such as 3 meters, 4 meters, 5 meters, 6 meters, 7 meters, 8 meters or 9 meters. When the coal is bituminous coal, the vertical distance between the vertical well and the directional drilling channel is 1-5 meters, such as 1.5 meters, 2 meters, 2.5 meters, 3 meters, 3.5 meters, 4 meters or 4.5 meters.

[0035] The fracturing method is any one of the methods of hydraulic fracturing, high-pressure air permeation, blasting or chemical solution breaking.

[0036] The ignition in the vertical well is any one of electric ignition, solid fuel ignition or coke ignition.

[0037] The gasification agent used for ignition is oxygen-containing gas and its oxygen concentration is ≥21%, such as 25%, 30%, 40%, 50%, 60%, 70%, 80%, 90% or 100%.

[0038] The pressure maintenance of the step (3) aims to keep pressure within 0.3-1.0Mpa, such as 0.4MPa, 0.5MPa, 0.6MPa, 0.7MPa, 0.8Mpa or 0.9Mpa. The pressure maintenance can be realized by continuously aerating the directional drilling.

[0039] The beneficial effects of the present invention will be further illustrated in the following referring to the specific embodiments and specific examples.

Embodiment 1

[0040] A method of underground gasification ignition comprising the following steps:

(1') creating a directional drilling and a vertical well to construct an underground gasification furnace, wherein the number of the vertical well is 1;

(2') pre-penetrating coal seam in the manner of cold fracturing;

(3') igniting in the vertical well at the end of the directional drilling.

(4') when the coal-burning volume is ≥ 0.5 cube meter, a ignition source being considered to be formed; then it being switched to the status that gas is introduced through the directional drilling, and gas is discharged through the vertical well and the gasification

channel being processed with firepower.

Embodiment 2

[0041] A method of underground gasification ignition comprising the following steps:

(1') creating a directional drilling well and vertical wells to construct an underground gasification furnace, wherein the number of the vertical wells is 2;

(2') pre-penetrating coal seam in the manner of cold fracturing;

(3') igniting in one of the vertical wells at the end of the directional drilling; gas being discharged through the other vertical well; pressure maintenance being made for the directional drilling during the process of the vertical well ignition and penetration;

(4') when the coal-burning volume is ≥ 0.5 cubic meter, a ignition source being considered to be formed; then it being switched according to the position of ignition hole to the status that air is introduced through the directional drilling, and gas is discharged through the ignition vertical well and the gasification channel being processed with firepower.

Embodiment 3

[0042] A method of underground gasification ignition comprising the following steps:

(1') creating a directional drilling and vertical wells to construct an underground gasification furnace, wherein the number of the vertical wells is 2;

(2') pre-penetrating coal seam in the manner of cold fracturing;

(3') igniting in one of the vertical wells at the end of the directional drilling; gas being discharged through the other vertical well; pressure maintenance being made for the directional drilling during the process of vertical well ignition and penetration;

(4') when the coal-burning volume is ≥ 0.5 cube meter, a ignition source is considered to be formed; then it being switched according to the position of ignition hole to the status that gas is introduced through the previously gas outlet vertical well, and gas is discharged through the ignition vertical well, and the gasification channel being processed with firepower.

Embodiment 5

[0043] A method of underground gasification ignition comprising the following steps:

(1') creating a directional drilling and vertical wells to construct an underground gasification furnace, wherein the number of vertical wells is at least 3;

(2') pre-penetrating coal seam in the manner of cold fracturing;

(3') igniting in one of the vertical wells at the end of the directional drilling; gas being discharged through at least one of the other vertical wells; pressure maintenance being made for the directional drilling during the process of vertical well ignition and penetration;

(4') when the coal-burning volume is ≥ 0.5 cube meter, a ignition source is considered to be formed; then it being switched according to the position of ignition hole to the status that gas is introduced through the directional drilling, and gas is discharged through the ignition vertical well, and the gasification channel being processed with firepower.

Embodiment 6

[0044] A method of underground gasification ignition comprising the following steps:

(1') creating a directional drilling and vertical wells to construct an underground gasification furnace, wherein the number of the vertical wells is at least 3;

(2') pre-penetrating the coal seam in the manner of cold fracturing;

(3') igniting in one of the vertical wells at the end of the directional drilling; gas being discharged through at least one of the other vertical wells; pressure maintenance being made for the directional drilling during the process of vertical well ignition and penetration;

(4') when the coal-burning volume is ≥ 0.5 cubic meter, a ignition source is considered to be formed; then it being switched according to the position of ignition hole to the status that air is introduced through the previous gas outlet vertical well, and gas is discharged through the ignition vertical well, and the gasification channel being processed with firepower.

Embodiment 7

[0045] A method of underground gasification ignition comprising the following steps:

(1') creating a directional drilling and vertical wells to construct an underground gasification furnace, wherein the number of the vertical wells is at least 3;

(2') pre-penetrating coal seam in the manner of cold fracturing;

(3') igniting in one of the vertical wells at the end of the directional drilling; gas being discharged through at least one of the other vertical wells; pressure maintenance being made for the directional drilling during the process of the vertical well ignition and penetration;

(4') when the coal-burning volume is ≥ 0.5 cubic meter, a ignition source is considered to be formed; then it being switched according to the position of ignition hole to the status that gas is introduced through the auxiliary well, and gas is discharged through the ignition vertical well, and the gasification channel being processed with firepower.

Example 1

[0046] Example 1 relates to a process, wherein one directional well and one vertical well are coordinately used for ignition in the brown coal seam. This process has the advantages of high fracturing efficiency, good dewatering effect of gasification furnace and high ignition efficiency, thereby providing superior precondition for industrial application of underground gasification furnace.
[0047] Referring to figures 1-3, the present example mainly comprises the following steps:

(1) an underground gasification furnace composed of one directional well and one vertical well along a line near an end of the directional drilling is constructed in the brown coal seam, wherein the coal seam is of 10 meters thick, the aperture diameter of the directional drilling is 150 mm, the channel is unsupported channel, the horizontal distance is 150m, the aperture diameter of the vertical well is 250 mm, which is located at the side of the directional drilling line, and the bottom of the casing tube is of about 2m away from the bottom plate of the coal seam and of 10 m away from the directional drilling channel vertically;

(2) high pressure air permeation method is used to conduct cold fracturing for the underground gasification furnace and the channel between the directional drilling and vertical well is penetrated.

(3) solid fuel is put down in the vertical well as the ignition well; air is used as gasification agent; gas is discharged through the directional drilling; ignition source is cultivated, wherein whether the ignition source is formed is determined by coal-burning amount at coal gas outlet hole;

(4) when the coal-burning volume is ≥ 0.5 cubic meter, the ignition source is considered to be formed; gas outlet hole and gas inlet hole are switched to the status that air is introduced through the directional drilling, and gas is discharged through the vertical well; reverse ignition is made to penetrate the gasification channel.

Example 2

[0048] Example 2 relates to a process, wherein one directional well and one vertical well are coordinately used for ignition in the bituminous coal seam. This process has the advantages of high fracturing efficiency, good dewatering effect of gasification furnace and high ignition efficiency, thereby providing superior precondition for industrial application of underground gasification furnace.
[0049] Referring to figures 4-5, the present example mainly comprises the following steps:

(1) an underground gasification furnace composed of one directional well and one vertical well along a line near an end of the directional drilling is built up in the bituminous coal seam, wherein the coal seam is of 10 meters thick, the aperture diameter of the directional drilling is 150 mm, the channel is unsupported channel, the horizontal distance is 120m, the aperture diameter of the vertical well is 300 mm, which is located at the side of the directional drilling line, and the bottom of the casing tube is about 2m away from the bottom plate of the coal seam and of 5m away from the directional drilling channel vertically;

(2) chemical solution breaking method is used to conduct cold fracturing for the underground gasification furnace and the channel between the directional drilling and vertical well is penetrated;

(3) coke is put down in the vertical well as the ignition well; air containing 35% oxygen is used as gasification agent; gas is discharged through the directional drilling; ignition source is cultivated, wherein whether the ignition source is formed is determined by the coal-burning amount at the coal gas outlet hole;

(4) when the coal-burning volume is ≥ 0.5 cubic meter, the ignition source is considered to be formed.; gas outlet hole and air inlet hole are switched to the status that air is introduced through the directional drilling, and gas is discharged through the vertical well; reverse ignition is made to penetrated the gasification channel.

Example 3

[0050] Example 3 relates to a process, wherein one directional well and three vertical wells are coordinately used for ignition in the brown coal seam. This process has the advantages of high fracturing efficiency, good dewatering effect of gasification furnace and high ignition efficiency, thereby providing superior precondition for the sequential operation of gasification furnace composed

of directional drilling.

[0051] Referring to figures 6-8, the present example mainly comprises the following steps:

(1) an underground gasification furnace composed of one directional well and 1#, 2# and 3# vertical wells along a line near an end of the directional drilling is constructed in the brown coal seam, wherein the coal seam is of 10 meters thick, the aperture diameter of the directional drilling is 150 mm, the channel is unsupported channel, the horizontal distance is 150m, the vertical wells is located at the two sides of the directional drilling line, the bottom of casing tube is about 2m away from the bottom plate of the coal seam, 1#, 2# and 3# wells have aperture diameters of 350mm, 350mm and 200mm, respectively, and are 8m, 10m and 10m, respectively, away from the directional drilling channel vertically and the 1# well is 30m and 10m, respectively, away from the 2# and 3# wells horizontally;

(2) high pressure air permeation method is used to conduct cold fracturing for the underground gasification furnace and the channel between the directional drilling and vertical well is penetrated;

(3) air is used as gasification agent and is continuously introduced in the directional drilling for pressure maintenance; ignition is made in 1# vertical well; gas is discharged through 2# vertical well; ignition source is cultivated, wherein the ignition source is considered to be formed when the coal-burning volume at the coal gas outlet hole reaches 1 cubic meter;

(4) after the ignition source is formed, air introduction in 1# ignition well is stopped and it is switched to the status that air is introduced in 3# vertical well and gas is discharged through 1# vertical well.

Example 4

[0052] Example 4 relates to a process, wherein one directional well and 2 vertical wells are coordinately used for ignition in the bituminous coal seam. This process has the advantages of high fracturing efficiency, good dewatering effect of underground gasification furnace, high ignition efficiency, and rapid holing through for the vertical well, thereby being beneficial to the sequential operation of gasification furnace composed of directional drilling.

[0053] Referring to figures 9-11, the present example mainly comprises of the following steps:

(1) an underground gasification furnace composed of one directional well and 1# and 2# vertical wells along a line near an end of the directional drilling is constructed in the bituminous coal seam, wherein the coal seam is of 10 meters thick, the aperture diameter of the directional drilling is 150 mm, the channel is disposed with sieve-tube support, the horizontal distance is 120m, the vertical wells is located at the two sides of the directional drilling line, the bottom of casing tube is about 2 m away from the bottom plate of the coal seam, both 1# and 2#wells have aperture diameters of 250 mm and are 5 m away from the directional drilling channel vertically, and the distance between the two wells is 25 meters;

(2) cold fracturing is made for the underground gasification furnace and the channel between the directional drilling and vertical well is penetrated;

(3) air containing 30% oxygen is used as gasification agent and is continuously introduced into the directional drilling for pressure maintenance; coke ignition is made in 2# vertical well; gas is discharged through 1# vertical well; ignition source is cultivated, wherein whether the ignition source is formed is determined by the coal-burning volume at the coal gas outlet hole;

(4) when the coal-burning volume is ≥ 0.5 cubic meter, the ignition source is considered to be formed; after the ignition source is formed, air introduction in 2# ignition well is stopped and air is introduced in the directional drilling instead; reverse ignition is made; air is continuously introduced in the directional drilling; gas outlet well is switched to 2# well to prolong the gasification channel.

[0054] The applicant states that the present invention employs the above embodiments to describe the detailed methods of the present invention, but the present invention is not limited to the detailed above methods, i.e. it does not mean that the present invention must rely on the above detailed method to be implemented. Persons skilled in the art should understand any improvement of the present invention, the equivalent replacement to the raw materials of the present invention product, the addition of auxiliary ingredients and the selection of specific mode all fall into the protection scope and disclosure scope of the present invention.

Claims

1. A method of underground gasification ignition, comprising of the following steps:

   - creating a directional drilling and vertical well(s) to construct an underground gasification furnace;
   - pre-penetrating the coal seam in the manner of cold fracturing;
   - igniting in the vertical well at the end of the

directional drilling.

2. The method according to claim 1, further comprising step (4) following the step (3), wherein after ignition source is formed, gas inlet hole and gas outlet hole are switched and gasification channel is processed with firepower.

3. The method according to claim 2, wherein the gas inlet hole and gas outlet hole are switched to the status that gas is discharged through the ignition vertical well.

4. The method according to claim 2, wherein the ignition source is considered to be formed when coal-burning volume is ≥ 0.5 cubic meter.

5. The method according to claim 1, wherein the number of the vertical well is 1; and wherein in the step (3) ignition is made in the vertical well at the end of the directional drilling and gas is discharged through the directional drilling.

6. The method according to claim 1, wherein the number of the vertical wells is at least 2; and wherein in the step (3), ignition is made in one of vertical wells at the end of the directional drilling, gas is discharged through at least one of the other vertical wells and pressure maintenance is made in the directional drilling at the same time.

7. The method according to claim 6, wherein the pressure maintenance is maintaining pressure within 0.3-1.0MP.

8. The method according to claim 1, wherein the coal is brown coal and the vertical distance between the vertical well and the directional drilling channel is 2-10 meters.

9. The method according to claim 1, wherein the coal is bituminous coal and the vertical distance between the vertical well and the directional drilling channel is 1-5 meters.

10. The method according to claim 1, wherein oxygen-containing gas is used as gasification agent for ignition and its oxygen concentration is ≥ 21%.

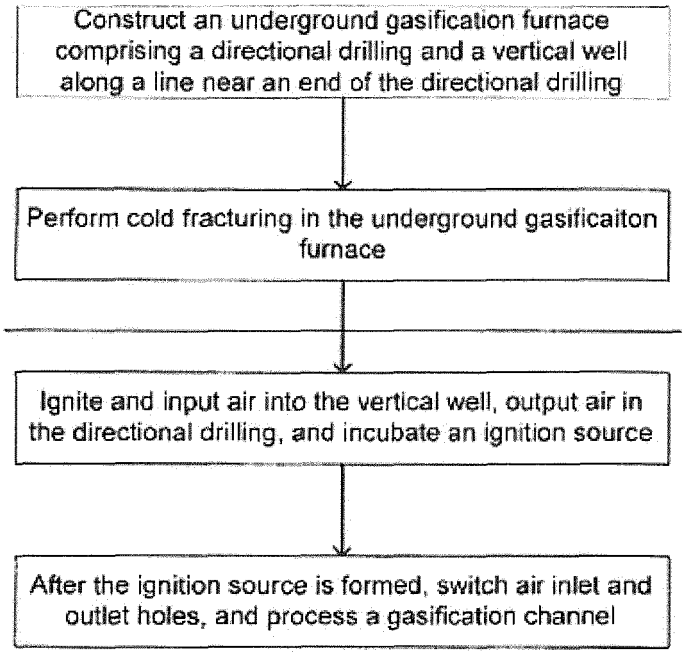
Construct an underground gasification furnace comprising a directional drilling and a vertical well along a line near an end of the directional drilling
Perform cold fracturing in the underground gasificaiton furnace
Ignite and input air into the vertical well, output air in the directional drilling, and incubate an ignition source
After the ignition source is formed, switch air inlet and outlet holes, and process a gasification channel

Fig. 1

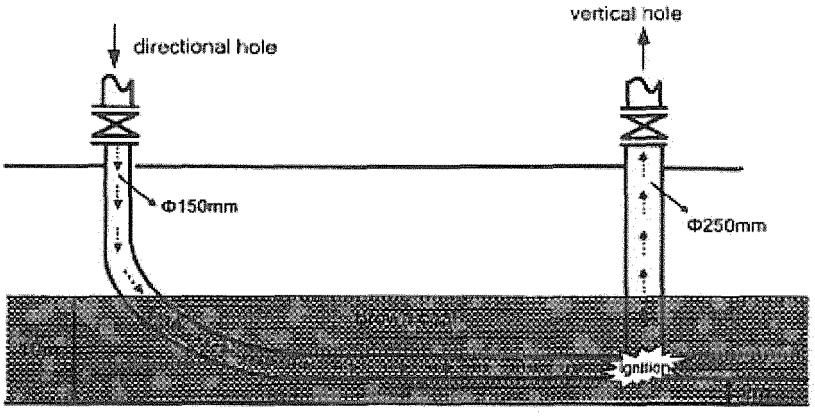
directional hole
vertical hole
Φ150mm
Φ250mm
ignition

Fig. 2


150m
directional hole
10m
vertical hole

Fig. 3

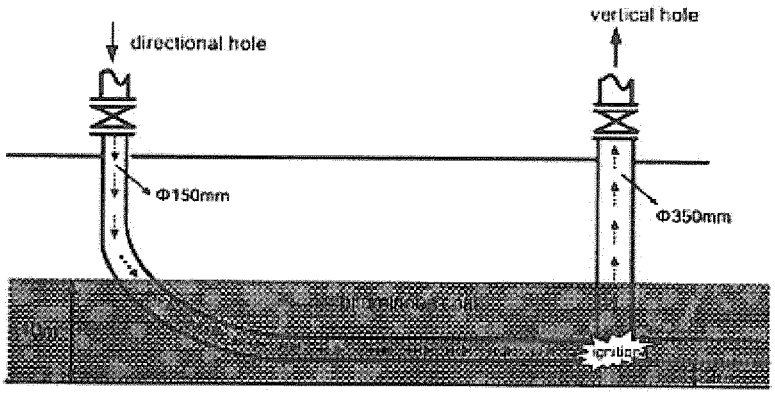
directional hole
vertical hole
Φ150mm
Φ350mm

Fig. 4

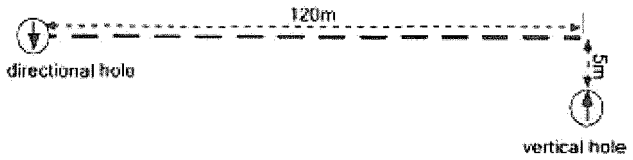
120m
directional hole
5m
vertical hole

Fig. 5

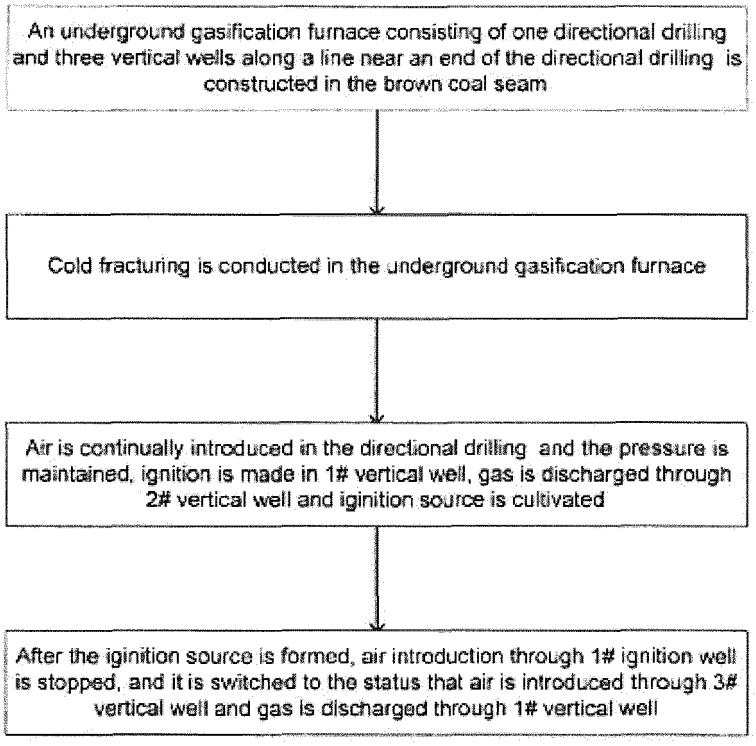
An underground gasification furnace consisting of one directional drilling and three vertical wells along a line near an end of the directional drilling is constructed in the brown coal seam
Cold fracturing is conducted in the underground gasification furnace
Air is continually introduced in the directional drilling and the pressure is maintained, ignition is made in 1# vertical well, gas is discharged through 2# vertical well and iginition source is cultivated
After the iginition source is formed, air introduction through 1# ignition well is stopped, and it is switched to the status that air is introduced through 3# vertical well and gas is discharged through 1# vertical well

Fig. 6

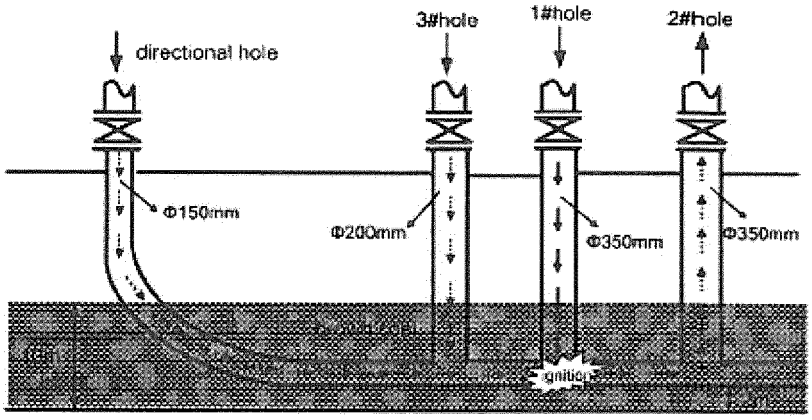
directional hole
3#hole
1#hole
2#hole
Φ150mm
Φ200mm
Φ350mm
Φ350mm

Fig. 7

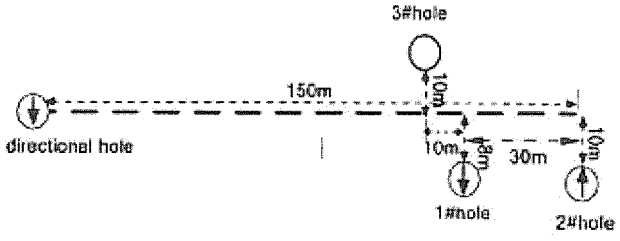
3#hole
150m
10m
directional hole
10m
3m
30m
10m
1#hole
2#hole

Fig. 8

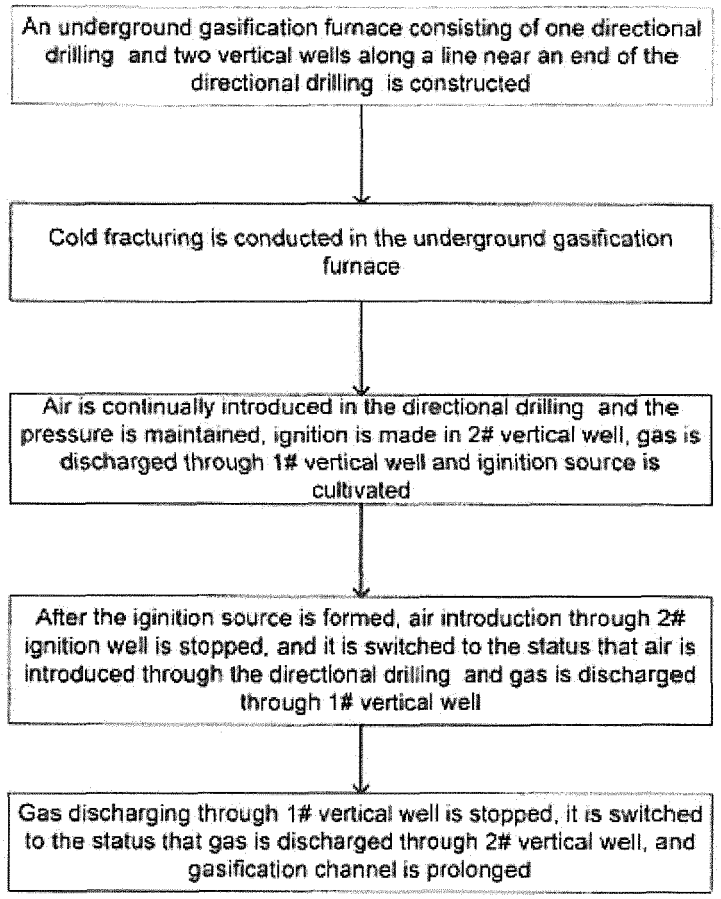
An underground gasification furnace consisting of one directional drilling and two vertical wells along a line near an end of the directional drilling is constructed
Cold fracturing is conducted in the underground gasification furnace
Air is continually introduced in the directional drilling and the pressure is maintained, ignition is made in 2# vertical well, gas is discharged through 1# vertical well and iginition source is cultivated
After the iginition source is formed, air introduction through 2# ignition well is stopped, and it is switched to the status that air is introduced through the directional drilling and gas is discharged through 1# vertical well
Gas discharging through 1# vertical well is stopped, it is switched to the status that gas is discharged through 2# vertical well, and gasification channel is prolonged

Fig. 9

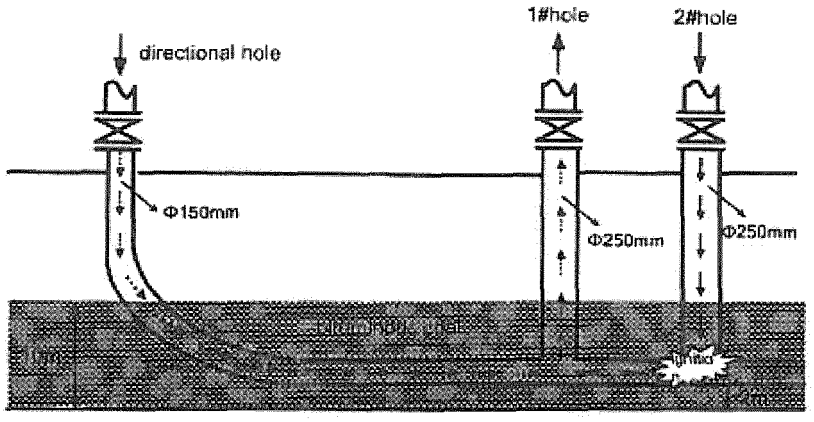
directional hole
1#hole
2#hole
Φ150mm
Φ250mm
Φ250mm

Fig. 10

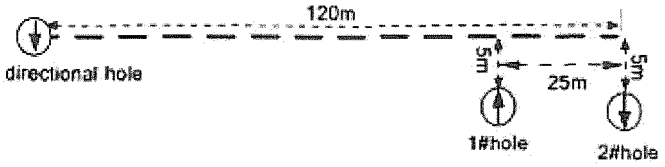
120m
directional hole
5m
25m
5m
1#hole
2#hole

Fig. 11

INTERNATIONAL SEARCH REPORT

International application No.
PCT/CN2014/074202

A. CLASSIFICATION OF SUBJECT MATTER

E21B 43/295 (2006.01) i; E21B 43/247 (2006.01) i

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

E21B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

CNTXT; CNKI; VEN: gasification, ignition, underground, coal, fire, ignite, crack

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	CN 103437748 A (ENN COAL GASIFICATION MINING CO LTD) 11 December 2013 (11.12.2013) description, paragraphs [0044]-[0059] and figures 3-7	1-10
A	CN 101315026 A (LI, Wenjun) 03 December 2008 (03.12.2008) the whole document	1-10
A	CN 103422848 A (ENN COAL GASIFICATION MINING CO LTD) 04 December 2013 (04.12.2013) the whole document	1-10
A	RU 2298093 C1 (PROMGAZ STOCK CO) 27 April 2007 (27.04.2007) the whole document	1-10
A	RU 2034139 C1 (SHTEIGER MINING TECH BUR) 30 April 1995 (30.04.1995) the whole document	1-10
A	UA 35883 U (UNIV NAT MINING) 10 October 2008 (10.10.2008) the whole document	1-10

☐ Further documents are listed in the continuation of Box C. ☒ See patent family annex.

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&"document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
12 September 2014	23 September 2014
Name and mailing address of the ISA State Intellectual Property Office of the P. R. China No. 6, Xitucheng Road, Jimenqiao Haidian District, Beijing 100088, China Facsimile No. (86-10) 62019451	Authorized officer LIU, Qiong Telephone No. (86-10) 62084154

Form PCT/ISA /210 (second sheet) (July 2009)

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/CN2014/074202

Patent Documents referred in the Report	Publication Date	Patent Family	Publication Date
CN 103437748 A	11 December 2013	None	
CN 101315026 A	03 December 2008	CN 101315026 B	31 August 2011
CN 103422848 A	04 December 2013	None	
RU 2298093 C1	27 April 2007	None	
RU 2034139 C1	30 April 1995	None	
UA 35883 U	10 October 2008	None	

Form PCT/ISA /210 (patent family annex) (July 2009)