

A device and a method of carbonaceous substance gasification

Field of the Invention

The present invention relates to a device and a method of carbonaceous substance gasification, especially for a device and a method to daily process more than 2000 ton of compressed pulverized coal to create synthesis gas.

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Back ground of the Invention

The development of the modern petrochemical industry nowadays is more focusing on large scale production, and the clean coal pulverization technique is directed into the scale expansion of high pressure pulverization equipment. But the existing pulverization equipments all have unsolved issues.

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The development of maximizing the single nozzle gasifiers is restricted by the transportation of the coal.

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Multiple nozzles gasifiers utilizing synthesis gas up-flowing process can be further expanded. However, the fluid cinder is flowing in a direction which is opposite to the synthesis gas flowing direction, so the moment the fluid cinder fall into the cinder pool, it will create certain amount of low temperature steam, which also flows opposite to the flowing direction of the fluid cinder into the chamber through the cinder exit, so that the temperature of the fluid cinder drops. Therefore, when the fluid cinder unevenly falls, it's usual that the fluid cinder concretes before reaching to the cinder pool. And since the heat is not enough to melt the solid cinder, so the solid cinder accumulates until the cinder exit is blocked, which eventually causes the equipment breakdown.

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Multiple nozzles gasifiers using synthesis gas down-flowing process also can be further expanded. Nevertheless, in order to fully utilizing the space in the chamber, usually the nozzles are arranged on the upper chamber where close to the top of the gasifiers, so during the process, the high temperature gas and fluid cinder keeps eroding the top of the gasifiers chamber, may cause the temperature excursion on the top of the chamber so that it may potentially lead to safety issues.

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SUMMARY OF THE INVENTION

One object of the present invention is to provide a device for carbonaceous substance powder gasification, which can reduce the possibilities of cinder jams and temperature excursion on the top of the chamber,

Another object of the present invention is to provide a method of carbonaceous substance powder gasification which can reduce the possibilities of cinder jams and temperature excursion on the top of the chamber,

On one hand, the present invention provides a method of carbonaceous substance powder gasification, characterized in: including the following steps:

i) The substance react with the oxy gasification agent and generate the crude synthesis gas in which the main components are CO and H₂ and the ashes in which main components is inorganic substance;

ii) Part of the high temperature crude synthesis gas and most of the ashes flow down to be cooled and purified, then the cooled and purified crude synthesis gas is delivered to the following procedures, the quenched ashes are exhausted from the equipment through the cinder exit,

wherein, said “most of” is for instance more than 50%, preferably more than 55%, preferably more than 60%, preferably more than 65%, preferably more than 70%, preferably more than 75%, preferably more than 80%, preferably more than 85%, etc.;

The rest part of the crude synthesis gas (for instance about 70%) and the ashes go up and mix with the cooling material, then enter into the cooling down reaction part, so that the carbon which is not fully reacted will again react with the supplemented gasification agent, then further improve the carbon conversion and lower the temperature, and the ratio of hydrogen-carbon is also raised; then the crude synthesis gas after the reaction and the ashes are cooled and purified, the ashes in the crude synthesis gas is eliminated, so the low temperature crude synthesis gas which is relatively clean, will be sent to the following procedures.

Said cooling material can also be water, water mist, water with the inert gas (CO₂, N₂), water with synthesis gas, or synthesis gas.

In the present invention, cooling is mainly realized by exchanging the heat with the cooling materials.

Purifying is realized mainly by utilizing gravity, inertial force to separate the gas and particles.

Lowering the temperature is meant to spray in certain amount of cooling material to lower the temperature of the mixed gas till a certain point(Ex. 900℃) ; cooling means to spray in excessive amount of cooling material, sufficiently exchanges the heat with the gas, so the temperature difference of before the cooling and after the cooling would be even bigger.

Purifying includes eliminating the dust and liquid drops in the synthesis gas.

According to one embodiment of the present invention, characterized in,

In step i) ,using nozzles to spray the carbonaceous substance and the gasification agent into the gasification reaction part of the device. According to one embodiment of the present invention, characterized in, in the environment of high temperature (1200℃～2000℃) and high pressure (0.1MPa～11MPa), the substance and the agent rapidly react. Usually under the certain pressure, the reaction temperature will be changing. In the present invention, said rapid reaction refers to the reaction which finishes in less than 10 seconds, 90% of the reaction finishes in 5 seconds.

According to one embodiment of the present invention, characterized in: in step ii), said “the rest part” is about 60%-80% (volume/ volume) of the total synthesis gas, preferably about 75% (volume/ volume).

According to one embodiment of the present invention, characterized in: in step ii), said gasification agent is water steam, water mist or CO₂, or the mix thereof.

According to one embodiment of the present invention, characterized in: in step ii),said temperature which is lowered by the reaction is between about 800℃-t₂ (softening temperature of the dust), herein the cinder i.e. the dust.

According to one embodiment of the present invention, characterized in, when the slag jam occurs at the slag outlet which causes the pressure rising at the slag outlet, increase the volume of gas going downwards, slowly raise the temperature at the slag outlet, so that the redundant slag can be melted, until the pressure at the slag outlet goes back to normal.

On the other hand, the present invention provides a carbonaceous substance powder gasification device, characterized in, including a bottom cooling purify part 1, a gasification reaction part 2, a cooling down reaction part 3, and a upper cooling purify part 4;

Said bottom cooling purify part 1 is set at the bottom of the device, its inlet is connected with the lower outlet of gasification reaction part 2;

Said gasification reaction part 2 is set at the lower part from the middle of the device.

- 5 Multiple nozzles are arranged around the periphery of gasification reaction part 2, the bottom outlet of said gasification reaction part 2 is connected with the bottom cooling purify part 1, and its upper outlet is connected with the cooling down reaction part 3.

- 10 Said cooling down reaction part 3 is set on the upper part from the middle of the device, its inlet is connected with the upper outlet of the gasification reaction part, a primary cooling device 31 is arranged at the connected part, to spray a proper amount of cooling materials, so on one hand cooling the gas, and on the other hand complementing the reactant, to further proceed the carbon gasification reaction in the cooling down reaction part 3, so that the hydrogen-carbon ratio of the synthesis gas can be increased;

- 15 Said upper cooling purify part 4 is set on the top of the device, its inlet is connected with the outlet of the cooling down reaction part3.

- 20 According to one embodiment of the present invention, characterized in, said bottom cooling purify part includes a rapid cooling device, a slag pool, a slag outlet, a synthesis gas outlet.

- 25 According to one embodiment of the present invention, characterized in, multiple nozzles are arranged around the periphery of said gasification reaction part, said nozzles can be set on 1 layer, or on multiple layers.

- 30 According to one embodiment of the present invention, characterized in, said nozzles are set at the lower part from the middle of the gasification chamber, so that during the reaction, the high temperature gas and cinders are far away from the top of the chamber, only part of the synthesis gas goes up, which avoids slag flushing and partially over heated.

According to one embodiment of the present invention, characterized in, a thermo scope is set inside said cooling down reaction part.

- 35 According to one embodiment of the present invention, characterized in, said upper cooling purify part includes a rapid cooling device, a dust pool, a synthesis gas outlet.

According to one embodiment of the present invention, characterized in, said primary

cooling device sprays proper amount of cooling materials to lower the temperature of the synthesis gas below t_2 (softening temperature of the dust), and above 800 °C.

5 According to one embodiment of the present invention, characterized in, said nozzles are arranged so that the reactants are sprayed to create a hedge effect (the axis of opposite nozzles coincide) or a rotary cut effect (relative to the axis of the nozzle, tangent with a same circle), said hedge effect or rotary cut effect can occur between nozzles on the same layer or on the different layers.

10 According to one embodiment of the present invention, characterized in, said nozzles are arranged at the lower part from the middle of the chamber.

15 Since part of the gas and the slag go downwards, so that it can avoid the water steam, which are created when cooling the slag, to go into the chamber and cool down the slag at the slag outlet, moreover, the high temperature crude synthesis gas goes down and provides enough heat at the slag outlet so that the solid slag at this place are accumulated; when the device is not operating stably, excessive slag is concreting at the slag outlet, in order to avoid the slag jam and the system break down, only need to increase the volume of the gas which goes downwards to melt the solid cinder.

20 If most of the gas is going upwards, in order to provide enough space for reaction, it only needs to arrange the nozzle at the lower-middle part of the chamber at the gasification reaction part, so that the high temperature zone of the gasification reaction part is far away from the top of the chamber, also reduces the erosion of the fire resistant material on the top of the chamber caused by the liquid slag flushing; also at the upper outlet, a cooling device is arranged, so that it can lower the temperature at the top of the chamber, and effectively avoid the overheating at the top of the chamber, eliminate the safety risks.

30 The method of present invention can be proceed in any suitable devices, preferably in the device of present invention.

With the above mentioned solutions, the technical effects of the present invention are quite obvious:

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1. The present invention uses a structure where the crude synthesis gas can exit from both the top and the bottom of the device, so on one hand to avoid the slag jamming at the slag exit which happens when using the upper gas exit solution, and on the other hand, to avoid the temperature excursion on the top of the device which occurs when using the bottom gas exit solution;
 2. Since the cooling down reaction part is added, the carbon conversion is improved,

and the ratio of hydrogen-carbon is raised;

3. With the structure where the gas can exit from both the top and the bottom of the device, the amount of the water which is used for rapid cooling is minimized;

4. The present invention uses multiple nozzles arrangement, which is good for fully reaction and the maximizing of the equipment.

BRIEF DESCRIPTION OF THE DRAWINGS

The above and other features of the present invention will become more apparent by describing in detail exemplary embodiments thereof with reference to the accompanying drawings, in which:

Fig.1 is an illustrative view of the gasification method of the present invention.

Fig. 2 is an illustrative view of a device of the present invention.

The numbers in the drawings indicate:

1.bottom cooling purify part; 11. downwards rapid device; 12. downstream pipe; 13, bottom synthesis gas outlet; 14. upstream pipe; 15. slag pool; 16. slag outlet; 2. gasification reaction part; 21. nozzle; 22. gasification chamber; 23. gasification chamber water cooling wall; 3. cooling down reaction part; 31. primary cooling device; 4. upper cooling purify part; 41. upstream rapid cooling device; 42. baffle pipe; 43. baffle device; 44. spray device; 45. segregation device; 46. upper synthesis gas outlet; 47. dust pool; 5. shell.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS OF THE INVENTION

Exemplary embodiments of the present disclosure will be described hereinafter in detail with reference to the attached drawings, wherein the like reference numerals refer to the like elements. The present disclosure may, however, be embodied in many different forms and should not be construed as being limited to the embodiment set forth herein.

Example 1

As shown in Fig.1, a method of carbonaceous substance powder gasification, characterize in, including the following steps:

Using 8 nozzles to spray the carbonaceous substance-coal powder with the gasification agent-mist of water steam into the gasification reaction part of the equipment2, in the environment of high temperature 1200 °C to 2000 °C, high pressure of 4.5MPa, rapidly react, and create crude synthesis gas whose main components are CO and H₂ and ashes whose main components is inorganic substance.

About 25% of the high temperature crude synthesis gas and most of the ashes flow down into the cooling purify part 1, the cleaned and purified crude synthesis gas is then delivered

to the following procedures, the quenched ashes are exhausted from the equipment through the cinder exit.

5 About 75% of the high temperature crude synthesis gas and the high temperature ashes flow up and mix with the water mist, and then flow into the cooling down reaction part 3, at this stage, the carbon which is not fully reacted will again react with the supplemented H₂O, then further improve the carbon conversion and lower the temperature, and the ratio of hydrogen-carbon is also raised.

10 After the reaction, the crude synthesis gas and the dust keep flowing up, been rapidly cooled, and then go into the upper cooling purify part 4, passing through the water bath, tray separation, cyclone separation, etc. to be cooled and purified, eliminate the dust in the crude synthesis gas, then the low temperature crude synthesis gas which is relatively clean will be then delivered to the following procedures.

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Example 2

See Fig.2, a device for carbonaceous substance gasification, characterized in, includes bottom cooling purify part 1, gasification reaction part 2, cooling down reaction part 3,
20 upper cooling purify part 4, shell 5.

Said bottom cooling purify part 1 is set at the bottom of the device, its inlet is connected with the lower outlet of gasification reaction part 2. Said bottom cooling purify part 1 includes downwards rapid cooling device 11, downstream pipe 12, bottom synthesis gas
25 outlet 13, upstream pipe 14, slag pool 15, slag outlet 16, etc.

Said gasification reaction part 2 is set at the lower part from the middle of the device. Six nozzles are arranged around the periphery of gasification reaction part 2; nozzles are arranged on one layer, the bottom outlet of said gasification reaction part 2 is connected with
30 the bottom cooling purify part 1, and its upper outlet is connected with the cooling down reaction part 3.

Said nozzles 21 are arranged so that the sprayed reactant can go in a path which creates a rotary cut (relative to the axis of the nozzle, tangent with a same circle), and it's a rotary cut
35 of the nozzles on the same layer.

Said cooling down reaction part 3 is set on the upper part from the middle of the device. Its inlet is connected with the upper outlet of the gasification reaction part 2. A primary cooling

device 31 is arranged at the connected part, to spray a proper amount of water mist, so that on one hand cooling the gas, and on the other hand complementing the reactant, to further proceed the carbon gasification reaction of the carbon in the dust at the cooling down reaction part 3.

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After the reaction, the crude synthesis gas keeps going up, passing through the upstream rapid cooling device 41 to be rapidly cooled, then passing through the baffle pipe 42, going into the dust pool 47 to be water bathed, then through the baffle device 43 to separate the big particles in the dust, going through the spray device 44 to be moisturized, then passing the segregation device 45 to remove the particles in the synthesis gas, then from the upper synthesis gas outlet 46 to be delivered to the following procedures.

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Said upper cooling purify part 4 is set on the top of the device, its inlet is connected with the outlet of the cooling down reaction part 3, it includes the upstream rapid cooling device 41, baffle pipe 42, baffle device 43, spray device 44, segregation device 45, upper synthesis gas outlet 46, dust pool 47, etc.

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Example 3

See Fig.2, a device for carbonaceous substance gasification, characterized in, includes bottom cooling purify part 1, gasification reaction part 2, cooling down reaction part 3, upper cooling purify part 4, shell 5.

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Said bottom cooling purify part 1 is set at the bottom of the device, its inlet is connected with the lower outlet of gasification reaction part 2. It includes downwards rapid cooling device 11, slag pool, slag outlet, synthesis gas outlet, etc.

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Said gasification reaction part 2 is set at the lower part from the middle of the device. Four nozzles are arranged on each layer around the periphery of gasification reaction part 2; nozzles are arranged on 2 layers. The bottom outlet of said gasification reaction part 2 is connected with the bottom cooling purify part 1, and its upper outlet is connected with the cooling down reaction part 3.

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Said nozzles 21 are arranged so that the reactants are sprayed to create a hedge effect (the axis of opposite nozzles coincide), said hedge effect can occurs between nozzles on different layers.

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Said cooling down reaction part 3 is set on the upper part from the middle of the device. Its inlet is connected with the upper outlet of the gasification reaction part 2. A primary cooling

device 31 is arranged at the connected part, to spray a proper amount of water mist, so that on one hand cooling the gas, and on the other hand complementing the reactant, then to further proceed the carbon gasification reaction of the carbon in the dust at the cooling down reaction part.

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After the reaction, the crude synthesis gas keeps going up to the upper cooling purify part 4 , the inlet of said upper cooling purify part 4 is connected with the outlet of the cooling down reaction part 3. The high temperature crude synthesis gas which enters into the upper cooling purify part 4 then passes through the upstream rapid cooling device 41 to be rapidly cooled, then through the baffle pipe 42, goes into the dust pool 47 to be water bathed, then through the baffle device 43 to separate the big particles in the dust, goes through the spray device 44 to be moisturized, then through the segregation device 45 to remove the particles in the synthesis gas, then from the upper synthesis gas outlet 46 to be delivered to the following procedures.

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What is claimed is,

1. A method of carbonaceous substance powder gasification, characterized in: including the following steps:

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i) The substance react with the oxy gasification agent and generate the crude synthesis gas in which the main components are CO and H₂ and the ashes in which main components is inorganic substance;

10 ii) Part of the high temperature crude synthesis gas and most of the ashes flow down to be cooled and purified, then the cooled and purified crude synthesis gas is delivered to the following procedures, the quenched ashes are exhausted from the equipment through the cinder exit;

15 the rest part of the crude synthesis gas and the ashes go up and mix with the cooling material, then enter into the cooling down reaction part, so that the carbon which is not fully reacted will again react with the supplemented gasification agent; the crude synthesis gas after the reaction and the ashes are cooled and purified, the ashes in the crude synthesis gas is eliminated, so that the low temperature crude synthesis gas which is relatively clean, will be
20 sent to the following procedures.

2. A method of carbonaceous substance powder gasification according to claim 1, characterized in:

in step i), using nozzles to spray the carbonaceous substance and the gasification agent into
25 the gasification reaction part of the device.

3. A method of carbonaceous substance powder gasification according to claim 1, characterized in:

in the environment of high temperature (1200°C ~ 2000°C) and high pressure (0.1MPa ~
30 11MPa), the substance and the agent rapidly react.

4. A method of carbonaceous substance powder gasification according to claim 1, characterized in:

in step ii), said "the rest part" is about 60%-80% (volume/ volume) of the total synthesis
35 gas, preferably about 75% (volume/ volume).

5. A method of carbonaceous substance powder gasification according to claim 1, characterized in:

in step ii), said gasification agent is water steam, water mist or CO₂, or the mix thereof.

6. A method of carbonaceous substance powder gasification according to claim 1,
characterized in :
in step ii), said temperature which is lowered by the reaction is between about 800°C-t₂
5 (softening temperature of the dust).

7.A method of carbonaceous substance powder gasification according to claim 1,
characterized in :
when the slag jam occurs at the slag outlet which causes the pressure rising at the slag outlet,
10 increase the volume of gas going downwards, slowly raise the temperature at the slag outlet,
so that the redundant slag can be melted, until the pressure at the slag outlet goes back to
normal.

8. A device for carbonaceous substance powder gasification, characterized in:
15 including a bottom cooling purify part (1), a gasification reaction part (2), a cooling down
reaction part (3), and an upper cooling purify part (4);

Said bottom cooling purify part is set at the bottom of the device, its inlet is connected with
the lower outlet of gasification reaction part;

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Said gasification reaction part is set at the lower part from the middle of the device, multiple
nozzles are arranged around the periphery of gasification reaction part, the bottom outlet of
said gasification reaction part is connected with the bottom cooling purify part, and its upper
outlet is connected with the cooling down reaction part;

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Said cooling down reaction part 3 is set on the upper part from the middle of the device, its
inlet is connected with the upper outlet of the gasification reaction part, a primary cooling
device is arranged at the connected part, to spray a proper amount of cooling materials;

30 Said upper cooling purify part is set on the top of the device, its inlet is connected with the
outlet of the cooling down reaction part.

9. A device for carbonaceous substance powder gasification according to claim 8,
characterized in:
35 said bottom cooling purify part includes a rapid cooling device, a slag pool, a slag outlet, a
synthesis gas outlet.

10.A device for carbonaceous substance powder gasification according to claim 8,
characterized in:

said multiple nozzles are arranged around the periphery of said gasification reaction part, said nozzles can be set on 1 layer, or on multiple layers.

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11. A device for carbonaceous substance powder gasification according to claim 8, characterized in:
athermo scope is set inside said cooling down reaction part.

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12. A device for carbonaceous substance powder gasification according to claim 8, characterized in:
said upper cooling purify part includes a rapid cooling device, a dust pool, a synthesis gas outlet.

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13. A device for carbonaceous substance powder gasification according to claim 8, characterized in:
said primary cooling device sprays proper amount of cooling materials to lower the temperature of the synthesis gas below t_2 (softening temperature of the dust), and above 800 °C.

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14. A device for carbonaceous substance powder gasification according to claim 8, characterized in:
said nozzles are arranged so that the reactants are sprayed to create a hedge effect (the axis of opposite nozzles coincide) or a rotary cut effect (relative to the axis of the nozzle, tangent with a same circle), said hedge effect or rotary cut effect can occur between nozzles on the same layer or on the different layers.

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15. A device for carbonaceous substance powder gasification according to any of the claims of 8-14, characterized in:

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said nozzles are arranged at the lower part from the middle of the chamber.