

Description

Title of Invention: COMBUSTIBLE GAS GENERATION SYSTEM

Technical Field

5 [0001]

The present disclosure relates to a combustible gas generation system.

Background Art

[0002]

10 For example, in Patent Literature 1 below, a device configured to extract hydrogen by thermally decomposing hydrocarbon gas such as methane via a catalyst is described. Since hydrocarbons are decomposed into hydrogen and carbon by thermal decomposition, carbon needs to be removed in order to extract hydrogen from hydrocarbons. In order to remove carbon, a filter is
15 generally used.

Citation List

Patent Literature

[0003]

20 Patent Literature 1: JP 2022-24997 A

Summary of Invention

Technical Problem

[0004]

25 Solids are deposited on the surface of the filter as time proceeds. Therefore, it is necessary to perform regeneration processing of the filter by blowing backwashing gas to the filter. Here, when nitrogen or the like as the backwashing gas is used, the concentration of nitrogen unexpectedly increases in the system that extracts hydrogen.

30

Solution to Problem

[0005]

In one aspect of the present disclosure, a combustible gas generation system is provided. The combustible gas generation system includes a reactor
35 and a filter device. The reactor is configured to thermally decompose a hydrocarbon supplied to the combustible gas generation system into carbon and hydrogen. The filter device is configured to capture carbon flowing out of the reactor. The combustible gas generation system can supply combustible gas in

the combustible gas generation system to the filter device as backwashing gas for regeneration processing of the filter device.

Brief Description of Drawings

5 [0006]

FIG. 1 is a diagram illustrating the configuration of a combustible gas generation system according to a first embodiment.

FIG. 2 is a diagram illustrating the configuration of the combustible gas generation system according to a second embodiment.

10 FIG. 3 is a diagram illustrating the configuration of the combustible gas generation system according to a third embodiment.

FIG. 4 is a diagram illustrating the configuration of the combustible gas generation system according to a fourth embodiment.

15 FIG. 5 is a diagram illustrating the configuration of the combustible gas generation system according to a fifth embodiment.

Description of Embodiments

[0007]

First Embodiment

20 Embodiments of the first embodiment will be described below with reference to the drawings.

FIG. 1 illustrates the configuration of a combustible gas generation system according to the present embodiment. The system illustrated in FIG. 1 is a system that generates hydrogen using methane as a feedstock. The hydrogen
25 may be, for example, fuel for a gas turbine for power generation.

[0008]

As illustrated in FIG. 1, methane supplied to the system is pressurized by a compressor 10 and discharged to a raw gas path 12. The methane in the raw gas path 12 is heated by a heat exchanger 42 and a heat exchanger 14 and
30 thereafter is supplied to a reactor 16. The reactor 16 is a device that decomposes methane into hydrogen and carbon by thermal decomposition. The reactor 16 is provided with a catalyst. An example of the catalyst includes iron. In the reactor 16, a state of the catalyst is, for example, in the form of a fluidized bed catalyst. In the reactor 16, the temperature of methane and
35 catalyst to be reacted is, for example, 750 to 900°C. In addition, the pressure in the reactor 16 is higher than the atmospheric pressure. The pressure in the reactor 16 may be, for example, several ata to several tens of ata.

[0009]

The methane, and the hydrogen and carbon generated by thermal decomposition flow out of the reactor 16 into an outlet path 18. The outlet path 18 passes through the heat exchanger 14. Thus, the methane supplied to the reactor 16 is heated by the high-temperature substances flowing out of the reactor 16. The outlet path 18 is connected to a cyclone 20. Therefore, mixture gas of methane and hydrogen flowing out of the heat exchanger 14 and carbon flow into the cyclone 20. The cyclone 20 is a centrifugal separation device that separates carbon from a mixture of the mixture gas and carbon. The cyclone 20 is connected to a filter device 22. This is a device that captures carbon that has failed to be separated by the cyclone 20.

[0010]

The filter device 22 is connected to a product gas path 40. The product gas path 40 passes through the heat exchanger 42. Therefore, the heat of the mixture gas flowing out of the filter device 22 is taken by the heat exchanger 42. In other words, methane supplied to the reactor 16 is heated by the heat of the mixture gas flowing out of the filter device 22. The product gas path 40 is connected to a cooler 44 downstream of the heat exchanger 42. Therefore, the mixture gas flowing out of the heat exchanger 42 is further cooled by the cooler 44.

[0011]

The mixture gas cooled by the cooler 44 is pressurized by a compressor 46 and then supplied to a hydrogen refiner 48. The hydrogen refiner 48 is, for example, a pressure swing adsorption (PSA). The hydrogen extracted from the mixture gas by the hydrogen refiner 48 is combustible gas generated by the system.

[0012]

The methane separated from the hydrogen by the hydrogen refiner 48 is discharged to an off-gas path 52. When the hydrogen refiner 48 performs processing of discharging the methane to the off-gas path 52, the hydrogen extracted from the mixture gas by the hydrogen refiner 48 is used. As a result, hydrogen is actually mixed in gas discharged to the off-gas path 52.

[0013]

A compressor 50 is provided in the off-gas path 52. Thus, the gas discharged from the hydrogen refiner 48 to the off-gas path 52 is pressurized. The off-gas path 52 is connected to the raw gas path 12 on the upstream side of the heat exchanger 42. Thus, the gas discharged from the hydrogen refiner 48 to the off-gas path 52 is returned to the reactor 16. Since the off-gas path 52 is

connected to the raw gas path 12, the raw gas path 12 contains traces of hydrogen.

[0014]

5 The carbon separated from the mixture gas by the cyclone 20 and the filter device 22 flows into a carbon transfer device 30. The carbon transfer device 30 temporarily stores therein carbon in the combustible gas generation system and then extracts the carbon to the outside of the combustible gas generation system.

[0015]

10 The raw gas path 12 is connected to a backwashing path 60. A connection point between the backwashing path 60 and the raw gas path 12 is upstream of a connection point between the raw gas path 12 and the off-gas path 52. The backwashing path 60 is provided with a buffer tank 62, a compressor 64, a heater 66, and a buffer tank 68 in this order from the upstream
15 side. The backwashing path 60 is connected to the filter device 22 on the downstream side of the buffer tank 68.

[0016]

Actions and Effects of Present Embodiment

20 As an integrated value of the inflow amount of the substances from the reactor 16 side to the filter device 22 increases, solids are deposited on the surface of the filter device 22. Here, the raw gas path 12 is connected to the backwashing path 60. Accordingly, methane can be blown as backwashing gas to the filter device 22. Therefore, regeneration processing of the filter device 22 can be realized by using the methane as the backwashing gas. The backwashing
25 gas is blown to the filter device 22, mixed with the mixture gas of methane and hydrogen from the reactor 16, and then flows through the product gas path 40 into the compressor 46.

[0017]

30 Incidentally, even when the regeneration processing is not performed, the mixture gas of hydrogen and methane flows upstream and downstream of the compressor 46. Therefore, the type of gas flowing upstream and downstream of the compressor 46 does not change regardless of whether the regeneration processing is performed. As a result, an unexpected increase of the concentration of incombustible gas in the system due to the regeneration
35 processing can be suppressed.

[0018]

According to the present embodiment described above, the following operational effects are further obtained.

(1-1) The off-gas path 52 is provided for returning the gas on the downstream side of the filter device 22 to the reactor 16. In this case, the backwashing gas used in the regeneration processing of the filter device 22 is returned via the off-gas path 52 to the reactor 16. Therefore, if the backwashing gas is nitrogen gas or the like unrelated to the gas used for generating hydrogen as a production target of the system, the concentration of the unrelated gas is likely to increase in the system. As a result, the utility value of methane as the backwashing gas is particularly high.

[0019]

(1-2) When the filter device 22 is regenerated by the backwashing gas, it is desirable that pressure of the backwashing gas supplied to the filter device 22 is sufficiently higher than pressure in the filter device 22 immediately before the regeneration processing. Accordingly, the compressor 64 is provided in the backwashing path 60. Therefore, methane supplied to the raw gas path 12 can be pressurized, and thus the high-pressure backwashing gas can be blown to the filter device 22.

[0020]

(1-3) The regeneration processing of the filter device 22 is executed intermittently. Therefore, the flow rate of methane supplied to the backwashing path 60 fluctuates. This may cause pressure fluctuation in the raw gas path 12. Accordingly, the buffer tank 62 is provided in the backwashing path 60. Therefore, pressure fluctuation on the upstream side of the buffer tank 62 in the backwashing path 60 due to the execution of the regeneration processing can be suppressed.

[0021]

(1-4) The temperature of methane in the raw gas path 12 is lower than the temperature of that in the filter device 22. Therefore, when the temperature of the backwashing gas is about the temperature of methane in the raw gas path 12, the backwashing gas flows into the filter device 22, thereby causing thermal shock in the filter device 22. Accordingly, the heater 66 is provided in the backwashing path 60, and thus the backwashing gas heated by the heater 66 is supplied to the filter device 22. This can suppress the occurrence of thermal shock in the filter device 22 due to the regeneration processing.

[0022]

(1-5) The buffer tank 68 is provided downstream of the heater 66. Therefore, the backwashing gas, the temperature of which is adjusted for the regeneration processing, can be temporarily stored. As a result, the temperature of the backwashing gas supplied to the filter device 22 during the regeneration

processing can be stabilized. In addition, pressure fluctuation on the upstream side of the filter device 22 can also be suppressed.

[0023]

Second Embodiment

5 The second embodiment will be described below with a focus on differences with the first embodiment by reference to the drawings.

[0024]

FIG. 2 illustrates the configuration of the combustible gas generation system according to the present embodiment. In FIG. 2, members
10 corresponding to the members illustrated in FIG. 1 are denoted by the same reference numerals for convenience.

As illustrated in FIG. 2, in the present embodiment, the off-gas path 52 is connected to the backwashing path 60. Thus, gas such as methane, which is off-gas separated from hydrogen by the hydrogen refiner 48, becomes the
15 backwashing gas.

[0025]

The present embodiment described above also provides the same operational effects as those of the first embodiment.

20 Third Embodiment

The third embodiment will be described below with a focus on differences with the first embodiment by reference to the drawings.

[0026]

FIG. 3 illustrates the configuration of the combustible gas generation system according to the present embodiment. In FIG. 3, members
25 corresponding to the members illustrated in FIG. 1 are denoted by the same reference numerals for convenience.

As illustrated in FIG. 3, in the present embodiment, hydrogen extracted by the hydrogen refiner 48 is pressurized by a compressor 70 and supplied to
30 the backwashing path 60.

[0027]

The present embodiment described above also provides the same operational effects as those of the first embodiment.

35 Fourth Embodiment

The fourth embodiment will be described below with a focus on differences with the first embodiment by reference to the drawings.

[0028]

FIG. 4 illustrates the configuration of the combustible gas generation system according to the present embodiment. In FIG. 4, members corresponding to the members illustrated in FIG. 1 are denoted by the same reference numerals for convenience.

5 The combustible gas generation system illustrated in FIG. 4 is a system that produces mixture gas of hydrogen and methane as a final product. Therefore, the hydrogen refiner 48 is not provided in the present embodiment. [0029]

10 According to the present embodiment described above, the same operational effects as the operational effects (1-2) to (1-5) of the first embodiment are achieved.

Fifth Embodiment

15 The fifth embodiment will be described below with a focus on differences with the fourth embodiment by reference to the drawings. [0030]

20 FIG. 5 illustrates the configuration of the combustible gas generation system according to the present embodiment. In FIG. 5, members corresponding to the members illustrated in FIG. 4 are denoted by the same reference numerals for convenience.

In the present embodiment, mixture gas of hydrogen and methane, which is a final product gas pressurized by the compressor 46, is supplied to the backwashing path 60.

[0031]

25 According to the present embodiment described above, the same operational effects as the operational effects (1-2) to (1-5) of the first embodiment are achieved.

Correlation

30 The correspondence between the matters in the embodiments described above and the matters described in the column of "Supplementary Notes" described below is as follows. In the following, the correlation is indicated for each number of the solution described in the column of "Supplementary Notes". [0032]

35 [1] Hydrocarbon corresponds to methane. Backwashing gas corresponds to methane in FIGS. 1 and 4, the mixture gas of methane and hydrogen in FIGS. 2 and 5, and hydrogen in FIG. 3.

[2] An off-gas path corresponds to the off-gas path 52.

[0033]

[3] A buffer tank corresponds to the buffer tanks 62 and 68.

[4] A heater corresponds to the heater 66.

[5] A compressor corresponds to the compressor 64.

5 [0034]

[6] A first buffer tank corresponds to the buffer tank 62. A second buffer tank corresponds to the buffer tank 68.

[7] The matters described in Solution 7 correspond to FIGS. 1 and 4.

[0035]

10 [8] The matters described in Solution 8 correspond to FIG. 2.

[9] The matters described in Solution 9 correspond to FIG. 3.

[10] The matters described in Solution 10 correspond to FIG. 5.

[0036]

Other Embodiments

15 Note that the present embodiment can be modified and implemented as follows. The present embodiment and the following modified examples can be implemented in combination with each other without technical contradictions.

[0037]

Regarding Compressor 64

20 •In FIGS. 1 and 4, if pressure of methane pressurized by the compressor 10 is sufficient as pressure of the backwashing gas, the compressor 64 may be omitted.

[0038]

•In FIG. 3, the compressor 70 may be omitted.

25 •In FIG. 3, if pressure of hydrogen pressurized by the compressor 70 is sufficient as pressure of the backwashing gas, the compressor 64 may be omitted.

[0039]

•In FIG. 5, the compressor 46 may be omitted.

30 •In FIG. 5, if pressure of the mixture gas of methane and hydrogen pressurized by the compressor 46 is sufficient as pressure of the backwashing gas, the compressor 64 may be omitted.

[0040]

Regarding Buffer Tank

35 •In FIG. 1 and FIGS. 3 to 5, when the compressor 64 is omitted as described in the column "Regarding Compressor 64" above, the buffer tank 62 may be omitted. Alternatively, the buffer tank 68 may be omitted. Alternatively, both of the buffer tanks 62 and 68 and may be omitted.

[0041]

- In FIG. 2, the buffer tank 68 may be omitted.

- In FIG. 2, for example, a buffer tank may be provided downstream of the compressor 50 in the off-gas path 52, and the buffer tank 62 may be omitted.

[0042]

Regarding Heater 66

- In FIGS. 1 and 4, the heater 66 may be omitted, for example, by connecting the backwashing path 60 between the heat exchanger 14 and the reactor 16 in the raw gas path 12.

[0043]

Regarding Hydrocarbon

- A hydrocarbon to be thermally decomposed into hydrogen and carbon is not limited to methane. For example, propane may be applied.

[0044]

Supplementary Notes

Solution 1. A combustible gas generation system including a reactor and a filter device, in which the reactor is configured to thermally decompose a hydrocarbon supplied to the combustible gas generation system into carbon and hydrogen, the filter device is configured to capture carbon flowing out of the reactor, and the combustible gas generation system is configured to supply combustible gas in the combustible gas generation system to the filter device as backwashing gas for regeneration processing of the filter device.

[0045]

In the above configuration, the combustible gas in the system is used as the backwashing gas. Therefore, an increase of the concentration of incombustible gas such as nitrogen in the system can be suppressed. Note that the combustible gas in the system may be a compound of carbon and hydrogen or hydrogen.

[0046]

Solution 2. The combustible gas generation system according to Solution 1 including a hydrogen refiner and an off-gas path, in which the hydrogen refiner is a device configured to extract hydrogen from mixture gas from which carbon is removed by the filter device, the mixture gas contains the hydrocarbon and the hydrogen, the off-gas path is a path through which off-gas is returned from the hydrogen refiner to the reactor, and the off-gas is gas obtained by removing the hydrogen from the hydrogen refiner and contains at least the hydrocarbon.

[0047]

In the above configuration, the backwashing gas flows through the off-gas path into the reactor. Therefore, when the backwashing gas is incombustibles gas such as nitrogen unrelated to the combustible gas in the system, the concentration of the unrelated gas may increase in the system. As a result, the utility value of combustible gas in the combustible gas generation system as the backwashing gas is particularly high.

[0048]

Solution 3. The combustible gas generation system according to Solution 1 or 2 including a backwashing path and a buffer tank, in which the backwashing path is configured to supply the backwashing gas to the filter device, and the buffer tank is provided in the backwashing path.

[0049]

In the above configuration, pressure fluctuation on the upstream side of the buffer tank in the backwashing path due to the execution of the regeneration processing can be suppressed.

Solution 4. The combustible gas generation system according to any one of Solutions 1 to 3 including a backwashing path and a heater, in which the backwashing path is configured to supply the backwashing gas to the filter device, and the heater is provided in the backwashing path.

[0050]

In the above configuration, by supplying the backwashing gas heated by the heater to the filter device, the occurrence of thermal shock in the filter device accompanying the regeneration processing can be suppressed.

Solution 5. The combustible gas generation system according to any one of Solutions 1 to 4 including a backwashing path and a compressor, in which the backwashing path is configured to supply the backwashing gas to the filter device, and the compressor is configured to pressurize the backwashing gas to be supplied to the filter device.

[0051]

In the above configuration, the backwashing gas is pressurized by the compressor, and thus the high-pressure backwashing gas can be blown to the filter device.

Solution 6. The combustible gas generation system according to any one of Solutions 1 to 5 including a backwashing path, a first buffer tank, a compressor, and a second buffer tank, in which the backwashing path is configured to supply the backwashing gas to the filter device, the first buffer tank and the second buffer tank are provided in the backwashing path, and the

compressor is configured to pressurize the backwashing gas supplied from the first buffer tank in the backwashing path and supply the pressurized backwashing gas to the second buffer tank.

[0052]

- 5 By providing the first buffer tank, pressure fluctuation upstream of the backwashing path can be suppressed. In addition, the pressurized backwashing gas can be stored in the second buffer tank.

[0053]

- 10 Solution 7. The combustible gas generation system according to any one of Solutions 1 to 6, in which the backwashing gas is the hydrocarbon supplied to the combustible gas generation system.

- 15 Solution 8. The combustible gas generation system according to any one of Solutions 1 to 6 including a hydrogen refiner, an off-gas path, and a backwashing path, in which the hydrogen refiner is a device configured to extract hydrogen from mixture gas from which carbon is removed by the filter device, the mixture gas contains the hydrocarbon and the hydrogen, the off-gas path is a path through which off-gas is returned from the hydrogen refiner to the reactor, the off-gas is gas obtained by removing the hydrogen from the hydrogen refiner and contains at least the hydrocarbon, and the backwashing path is configured to supply the off-gas as the backwashing gas to the filter device by being branched from the off-gas path to be connected to the filter device.

[0054]

- 25 In the above configuration, the backwashing gas flows through the off-gas path into the reactor. Therefore, when the backwashing gas is incombustibles gas such as nitrogen unrelated to the combustible gas in the system, the concentration of the unrelated gas may increase in the system. As a result, the utility value of off-gas as the backwashing gas is particularly high.

[0055]

- 30 Solution 9. The combustible gas generation system according to any one of Solutions 1 to 6 including a hydrogen refiner and a backwashing path, in which the hydrogen refiner is a device configured to extract hydrogen from mixture gas from which carbon is removed by the filter device, and the backwashing path is configured to supply the hydrogen extracted by the hydrogen refiner as the backwashing gas to the filter device.

[0056]

In the above configuration, the hydrogen extracted by the hydrogen refiner is used as the backwashing gas. Therefore, an increase of the

concentration of incombustible gas such as nitrogen in the system can be suppressed.

Solution 10. The combustible gas generation system according to any one of Solutions 1 to 6, in which the combustible gas generation system is
5 configured to generate, as generation target, mixture gas from which the carbon is removed by the filter device, the mixture gas contains the hydrogen and the hydrocarbon, and the backwashing gas is the mixture gas.
[0057]

In the above configuration, the mixture gas that is the generation target
10 is used as the backwashing gas. Therefore, an increase of the concentration of incombustible gas such as nitrogen in the system can be suppressed.

Claims

[Claim 1]

A combustible gas generation system comprising:
a reactor; and
a filter device, wherein
the reactor is configured to thermally decompose a hydrocarbon supplied to the combustible gas generation system into carbon and hydrogen,
the filter device is configured to capture carbon flowing out of the reactor, and
the combustible gas generation system is configured to supply combustible gas in the combustible gas generation system to the filter device as backwashing gas for regeneration processing of the filter device.

[Claim 2]

The combustible gas generation system according to claim 1 comprising:
a hydrogen refiner; and
an off-gas path, wherein
the hydrogen refiner is a device configured to extract hydrogen from mixture gas from which carbon is removed by the filter device,
the mixture gas contains the hydrocarbon and the hydrogen,
the off-gas path is a path through which off-gas is returned from the hydrogen refiner to the reactor, and
the off-gas is gas obtained by removing the hydrogen from the hydrogen refiner and contains at least the hydrocarbon.

[Claim 3]

The combustible gas generation system according to claim 1 comprising:
a backwashing path; and
a buffer tank, wherein
the backwashing path is configured to supply the backwashing gas to the filter device, and
the buffer tank is provided in the backwashing path.

[Claim 4]

The combustible gas generation system according to claim 1 comprising:
a backwashing path; and
a heater, wherein

the backwashing path is configured to supply the backwashing gas to the filter device, and
the heater is provided in the backwashing path.

[Claim 5]

The combustible gas generation system according to claim 1 comprising:
a backwashing path; and
a compressor, wherein
the backwashing path is configured to supply the backwashing gas to the filter device, and
the compressor is configured to pressurize the backwashing gas to be supplied to the filter device.

[Claim 6]

The combustible gas generation system according to claim 1 comprising:
a backwashing path;
a first buffer tank;
a compressor; and
a second buffer tank, wherein
the backwashing path is configured to supply the backwashing gas to the filter device,
the first buffer tank and the second buffer tank are provided in the backwashing path, and
the compressor is configured to pressurize the backwashing gas supplied from the first buffer tank in the backwashing path and supply the pressurized backwashing gas to the second buffer tank.

[Claim 7]

The combustible gas generation system according to claim 1, wherein the backwashing gas is the hydrocarbon supplied to the combustible gas generation system.

[Claim 8]

The combustible gas generation system according to claim 1 comprising:
a hydrogen refiner;
an off-gas path; and
a backwashing path, wherein

the hydrogen refiner is a device configured to extract hydrogen from mixture gas from which carbon is removed by the filter device,
the mixture gas contains the hydrocarbon and the hydrogen,
the off-gas path is a path through which off-gas is returned from the hydrogen refiner to the reactor,
the off-gas is gas obtained by removing the hydrogen from the hydrogen refiner and contains at least the hydrocarbon, and
the backwashing path is configured to supply the off-gas as the backwashing gas to the filter device by being branched from the off-gas path to be connected to the filter device.

[Claim 9]

The combustible gas generation system according to claim 1 comprising:
a hydrogen refiner; and
a backwashing path, wherein
the hydrogen refiner is a device configured to extract hydrogen from mixture gas from which carbon is removed by the filter device, and
the backwashing path is configured to supply the hydrogen extracted by the hydrogen refiner as the backwashing gas to the filter device.

[Claim 10]

The combustible gas generation system according to claim 1, wherein
the combustible gas generation system is configured to generate, as a generation target, mixture gas from which the carbon is removed by the filter device,
the mixture gas contains the hydrogen and the hydrocarbon, and
the backwashing gas is the mixture gas.