

DESCRIPTION

Title of Invention

PYROLYSIS TREATMENT SYSTEM AND PYROLYSIS TREATMENT METHOD

5 Technical Field

[0001] The present invention relates to a pyrolysis treatment system and a pyrolysis treatment method for pyrolyzing oxygen-containing treatment object, such as biomass and municipal waste, and recovering oil from the generated pyrolysis gas.

Background Art

10 [0002] Material recycling and chemical recycling, which treat and reuse materials that contain oxygen, such as biomass and municipal waste, have been developed. In particular, the chemical recycling, which uses a pyrolysis chamber to recover oil from biomass, is attracting attention.

[0003] A fluidized-bed furnace is used in the chemical recycling. This fluidized-bed
15 furnace has a structure such that the inside of the furnace is divided by a partition wall into a pyrolysis chamber and a medium regeneration chamber. Treatment object, such as biomass, is fed into the pyrolysis chamber while fluidized medium circulates between the pyrolysis chamber and the medium regeneration chamber. The treatment object is heated by the fluidized medium in the pyrolysis chamber, and most of the treatment object is
20 gasified in pyrolysis. The residue of the treatment object is transported by the fluidized medium to the medium regeneration chamber. The residue of the treatment object is burned in the medium regeneration chamber to heat the fluidized medium. The heated fluidized medium moves into the pyrolysis chamber and functions as a heat source in the pyrolysis chamber. The fluidized-bed furnace in which the fluidized medium circulates
25 inside the furnace in this way is called an internal circulating fluidized-bed gasification system.

[0004] The treatment object generates pyrolysis gas by pyrolysis. Gaseous hydrocarbon contained in the pyrolysis gas is condensed, so that cracked oil is recovered. The above-

mentioned internal circulating fluidized-bed gasification system is expected to provide a technology that can pyrolyze the treatment object and recover cracked oil and cracked gas as pyrolysis products from the treatment object.

Citation List

5 **Patent Literature**

[0005] Patent document 1: Japanese Patent No. 6933577

Summary of Invention

Technical Problem

[0006] However, the cracked oil recovered by the pyrolysis of the treatment object
10 contains a lot of oxygen, and therefore the cracked oil is poor in quality as a chemical feedstock or fuel, making it difficult to use the cracked oil as a basic chemical product or use the cracked oil in engines or high-efficiency power generation equipment. In particular, bio-oil generated by the pyrolysis of biomass has a high oxygen content rate, and a calorific value of the bio-oil is less than half that of petroleum-based fuel oil.
15 Furthermore, water and acid by-products corrode equipment, and can cause fouling of the equipment and catalyst due to increased coke production.

[0007] Therefore, the present invention provides a pyrolysis treatment system and a pyrolysis treatment method that can recover high-quality oil from an oxygen-containing treatment object, such as biomass.

20 **Solution to Problem**

[0008] In an embodiment, there is a pyrolysis treatment system for treating a treatment object containing oxygen, comprising: a pyrolysis chamber configured to generate pyrolysis gas by pyrolyzing the treatment object; a hydrogenation reforming device configured to hydrogenate the pyrolysis gas; and a condenser configured to condense oil
25 component and moisture contained in the hydrotreated pyrolysis gas to recover oil and light gas separately.

[0009] In an embodiment, the pyrolysis treatment system further comprises: a gas separator configured to recover a reducing gas from the light gas; and a reducing-gas

transfer line configured to transfer the reducing gas to at least one of the pyrolysis chamber and the hydrogenation reforming device.

In an embodiment, the pyrolysis chamber comprises a pyrolysis chamber of a fluidized-bed furnace, the fluidized-bed furnace includes the pyrolysis chamber and a medium regeneration chamber through which a fluidized medium circulates, and the pyrolysis treatment system further comprises a fuel line configured to supply the light gas from which the reducing gas has been removed by the gas separator to the medium regeneration chamber.

[0010] In an embodiment, the pyrolysis treatment system further comprises a solid-gas separator disposed between the pyrolysis chamber and the hydrogenation reforming device, the solid-gas separator being configured to separate particles from the pyrolysis gas discharged from the pyrolysis chamber.

In an embodiment, the pyrolysis treatment system further comprises: a heat recovery device configured to supply heat to the pyrolysis chamber; and a fuel line configured to supply, to the heat recovery device, the light gas from which the reducing gas has been removed by the gas separator.

In an embodiment, the condenser includes an oil scrubber and a water scrubber.

In an embodiment, the pyrolysis treatment system further comprises an oil-water separator configured to divide oil-water mixture, discharged from the water scrubber, into oil and water.

[0011] In an embodiment, there is provided a pyrolysis treatment method for treating a treatment object containing oxygen, comprising: pyrolyzing the treatment object in a pyrolysis chamber to generate pyrolysis gas; hydrogenating the pyrolysis gas by a hydrogenation reforming device; and condensing oil component and moisture contained in the hydrogenated pyrolysis gas by a condenser to recover oil and light gas separately.

[0012] In an embodiment, the pyrolysis treatment method further comprises recovering a reducing gas from the light gas by a gas separator; and transferring the reducing gas to at least one of the pyrolysis chamber and the hydrogenation reforming device.

In an embodiment, the pyrolysis chamber comprises a pyrolysis chamber of a fluidized-bed furnace, the fluidized-bed furnace includes the pyrolysis chamber and a medium regeneration chamber through which a fluidized medium circulates, and the pyrolysis treatment method further comprises supplying, to the medium regeneration
5 chamber, the light gas from which the reducing gas has been removed by the gas separator.

[0013] In an embodiment, the pyrolysis treatment method further comprises separating particles from the pyrolysis gas discharged from the pyrolysis chamber by a solid-gas separator disposed between the pyrolysis chamber and the hydrogenation reforming device.

In an embodiment, the pyrolysis treatment method further comprises: supplying
10 the light gas from which the reducing gas has been removed by the gas separator to a heat recovery device to combust the light gas; and supplying heat generated by the combustion of the light gas to the pyrolysis chamber.

In an embodiment, the condenser includes an oil scrubber and a water scrubber.

In an embodiment, the pyrolysis treatment method further comprises dividing oil-
15 water mixture, discharged from the water scrubber, into oil and water.

Advantageous Effects of Invention

[0014] The hydrogenation device adds the hydrogen gas to the pyrolysis gas to cause the reaction of the oxygen contained in the pyrolysis gas with the hydrogen. The moisture produced by the hydrogenation is condensed in the condenser. The liquid oil and the
20 water are separated, so that the oil can be recovered. In particular, because the hydrogenation is carried out before the moisture and oil components are condensed, the high heat of the pyrolysis gas coming out of the pyrolysis chamber can be used directly for the hydrogenation of the pyrolysis gas.

Brief Description of Drawings

25 [0015]

[FIG. 1] FIG. 1 is a block diagram showing an embodiment of a pyrolysis treatment system;
[FIG. 2] FIG. 2 is a block diagram showing another embodiment of a pyrolysis treatment system;

[FIG. 3] FIG. 3 is a block diagram showing still another embodiment of a pyrolysis treatment system;

[FIG. 4] FIG. 4 is a block diagram showing still another embodiment of a pyrolysis treatment system;

5 [FIG. 5] FIG. 5 is a block diagram showing still another embodiment of a pyrolysis treatment system;

[FIG. 6] FIG. 6 is a block diagram showing still another embodiment of a pyrolysis treatment system; and

[FIG. 7] FIG. 7 is a block diagram showing still another embodiment of a pyrolysis
10 treatment system;

Description of Embodiments

[0016] Hereinafter, embodiments of the present invention will be described with reference to the drawings. FIG. 1 is a block diagram showing an embodiment of a
15 pyrolysis treatment system for treating a treatment object containing oxygen. The treatment object to be treated by the pyrolysis treatment system is a material containing oxygen, such as biomass or urban waste. In the embodiments described below, biomass, which is an example of the treatment object, is treated by the pyrolysis treatment system.

[0017] As shown in FIG. 1, the pyrolysis treatment system includes a pyrolysis chamber
20 1 configured to generate pyrolysis gas by pyrolysis of biomass, a hydrogenation reforming device 5 configured to perform hydrogenation on the pyrolysis gas, and a condenser 7 configured to condense oil component and moisture contained in the pyrolysis gas that has been subjected to the hydrogenation to recover oil and light gas separately. The pyrolysis chamber 1 is configured to generate the pyrolysis gas by heating and pyrolyzing the
25 biomass. A decomposition catalyst may be added to the pyrolysis chamber 1 in order to promote the pyrolysis. The type of pyrolysis chamber 1 in this embodiment is not particularly limited. For example, the pyrolysis chamber 1 may be a fluidized-bed pyrolysis chamber described later or a kiln pyrolysis chamber.

[0018] The hydrogenation reforming device 5 is disposed downstream of the pyrolysis chamber 1, and the pyrolysis gas generated by the pyrolysis chamber 1 is delivered to the hydrogenation reforming device 5. The hydrogenation reforming device 5 adds hydrogen gas to the pyrolysis gas under a high temperature to cause a reaction of the oxygen
5 contained in the pyrolysis gas and the hydrogen. The pyrolysis gas delivered to the hydrogenation reforming device 5 is a high-temperature gas (e.g., 400 to 600°C) discharged from the pyrolysis chamber 1. Therefore, the hydrogenation reforming device 5 can directly utilize the high heat of the pyrolysis gas to perform the hydrogenation on the pyrolysis gas.

10 [0019] The pyrolysis treatment system includes a hydrogen-gas supply source 10 configured to supply the hydrogen gas to the hydrogenation reforming device 5. The hydrogen-gas supply source 10 is coupled to the hydrogenation reforming device 5. An example of the hydrogen-gas supply source 10 is a hydrogen-gas cylinder.

[0020] The condenser 7 is disposed downstream of the hydrogenation reforming device
15 5. The condenser 7 is configured to cool the pyrolysis gas to condense the oil component and moisture contained in the pyrolysis gas. Specific examples of the condenser 7 include a heat exchanger (e.g., a multi-tube heat exchanger, a spiral heat exchanger, a plate heat exchanger, etc.), an oil scrubber, a water scrubber, and a combination thereof.

[0021] In one example, the pyrolysis gas is cooled to 40°C by the condenser 7. Thus, in
20 the condenser 7, the oil components and the moisture having boiling points of 40°C or higher are condensed and discharged as an oil-water mixture. The oil-water mixture and light gas are discharged separately from the condenser 7. The oil-water mixture is delivered to an oil reservoir 12. The oil-water mixture is divided into oil and water in the oil reservoir 12. The oil is recovered as cracked oil or reformed oil, and the water is
25 drained from a bottom of the oil reservoir 12.

[0022] The light gas discharged from the condenser 7 includes, for example, hydrogen (H₂), methane (CH₄), ethane (C₂H₆), liquefied petroleum gas (LPG), carbon monoxide (CO), and carbon dioxide (CO₂). The light gas is delivered to a combustion treatment

device (not shown) and is burned.

[0023] The hydrogenation reforming device 5 is disposed upstream of the condenser 7, and performs the hydrogenation on the pyrolysis gas before the pyrolysis gas is cooled by the condenser 7 (i.e., before the moisture and the oil component in the pyrolysis gas are condensed). Therefore, the hydrogenation reforming device 5 can directly use the high heat of the pyrolysis gas discharged from the pyrolysis chamber 1 for the hydrogenation, and does not require a heating device or energy for heating the pyrolysis gas.

[0024] FIG. 2 is a block diagram showing an embodiment of a pyrolysis treatment system. Configuration and operation of this embodiment that will not be particularly described are the same as those of the embodiment described with reference to FIG. 1, and therefore duplicated descriptions will be omitted. The pyrolysis treatment system of the embodiment shown in FIG. 2 further includes a gas separator 15 configured to recover a reducing gas from the light gas that has been discharged from the condenser 7, and a reducing-gas transfer line 17 configured to transfer the reducing gas containing hydrogen gas to the pyrolysis chamber 1 and the hydrogenation reforming device 5.

[0025] The gas separator 15 is disposed downstream of the condenser 7, and the light gas discharged from the condenser 7 is delivered to the gas separator 15. Specific configuration of the gas separator 15 is not particularly limited. For example, a pressure swing adsorption device (PSA) or a gas separation membrane can be used for the gas separator 15. The reducing gas recovered in the gas separator 15 is transferred through the reducing-gas transfer line 17 to the pyrolysis chamber 1 and, if necessary, to the hydrogenation reforming device 5.

[0026] In the embodiment shown in FIG. 2, the gas separator 15 is configured to recover hydrogen gas, methane, ethane, and carbon monoxide gas, which have small molecular weights, from the light gas. The hydrogen gas, the carbon monoxide gas, etc., recovered by the gas separator 15 are transferred as the reducing gas through the reducing-gas transfer line 17 to the pyrolysis chamber 1 and, if necessary, to the hydrogenation reforming device 5. The reducing gas containing at least hydrogen gas is delivered to the pyrolysis chamber

1, so that generation of coke during the pyrolysis of biomass can be suppressed.

[0027] The hydrogen-gas supply source 10 described above is coupled to the reducing-gas transfer line 17. In this embodiment, the reducing-gas transfer line 17 extends from the gas separator 15 to both the pyrolysis chamber 1 and the hydrogenation reforming device 5. The hydrogen gas that has been delivered to the pyrolysis chamber 1 functions as a purge gas in the pyrolysis chamber 1. The purge gas is a gas for discharging the pyrolysis gas remaining in the pyrolysis chamber 1 to the downstream side, and may be used to adjust a residence time of the pyrolysis gas. When an amount of the reducing gas required in the pyrolysis chamber 1 and the hydrogenation reforming device 5 exceeds an amount of the purge gas, the required reducing gas is directly supplied to the hydrogenation reforming device 5.

[0028] In one embodiment, the reducing-gas transfer line 17 may extend from the gas separator 15 to either the pyrolysis chamber 1 or the hydrogenation reforming device 5. In this configuration, the reducing gas recovered in the gas separator 15 is delivered to the hydrogenation reforming device 5 either via the pyrolysis chamber 1 or without passing through the pyrolysis chamber 1.

[0029] The hydrogen gas contained in the light gas that has been discharged from the condenser 7 is recovered by the gas separator 15 and used again for the hydrogenation in the hydrogenation reforming device 5. Specifically, the hydrogen gas required for the hydrogenation is consumed while circulating between the hydrogenation reforming device 5 and the gas separator 15. According to this embodiment, an amount of hydrogen gas consumed can be reduced. Depending on the amount of hydrogen gas required for the hydrogenation in the hydrogenation reforming device 5, the hydrogen gas may be supplied from the hydrogen-gas supply source 10 through the reducing-gas transfer line 17 to the hydrogenation reforming device 5.

[0030] The pyrolysis treatment system further includes a heat recovery device 20 configured to supply heat to the pyrolysis chamber 1, and a fuel line 21 configured to supply, to the heat recovery device 20, the light gas from which the reducing gas has been removed

by the gas separator 15. The light gas from which the reducing gas has been removed contains, for example, liquefied petroleum gas (LPG), such as propane or butane, which has larger molecular weight, and carbon dioxide (CO₂), and is combusted as fuel in the heat recovery device 20 to generate heat. The heat generated in the heat recovery device 20 is consumed as a heat source for the pyrolysis chamber 1 (for example, a kiln-type pyrolysis chamber).

[0031] FIG. 3 is a block diagram showing an embodiment of a pyrolysis treatment system. Configuration and operation of this embodiment that will not be particularly described are the same as those of the embodiment described with reference to FIG. 2, and therefore duplicated descriptions will be omitted. The pyrolysis treatment system of the embodiment shown in FIG. 3 further includes a hydrocracker 25 coupled to the oil reservoir 12, and a distillation tower 28 coupled to the hydrocracker 25.

[0032] A part or all of the oil in the oil reservoir 12 is delivered to the hydrocracker 25 by a pump 30. The hydrocracker 25 is configured to further perform hydrogenation on the oil recovered in the oil reservoir 12 at a high temperature (e.g., 400 to 600°C) and under pressure (e.g., 1 MPa or more). Hydrogen gas to be used in the hydrogenation in the hydrocracker 25 is supplied from the hydrogen-gas supply source 10. Trace amounts of oxygen, sulfur, nitrogen, etc. contained in the oil are removed by the hydrogenation in the hydrocracker 25.

[0033] The oil hydrogenated by the hydrocracker 25 is delivered to the distillation tower 28 where the oil is divided into light oil and heavy oil. The hydrogen, hydrogen sulfide, and ammonia discharged from the distillation tower 28 are delivered to the gas separator 15. Water condensed and separated in the distillation tower 28 is drained from an auxiliary facility of the distillation tower 28.

[0034] The hydrocracker 25 and the distillation tower 28 shown in FIG. 3 are appropriately provided based on the quality required for the oil recovered in the oil reservoir 12.

[0035] FIG. 4 is a block diagram showing an embodiment of a pyrolysis treatment system

using a fluidized-bed furnace. Configuration and operation of this embodiment that will not be particularly described are the same as those of the embodiment described with reference to FIG. 3, and therefore duplicated descriptions will be omitted.

[0036] The pyrolysis treatment system of the embodiment shown in FIG. 4 includes a fluidized-bed furnace 40 configured to pyrolyze and combust biomass, which is an example of an oxygen-containing treatment object. The fluidized-bed furnace 40 includes pyrolysis chamber 1 configured to pyrolyze the biomass and generate pyrolysis gas, and a medium regeneration chamber 44 configured to combust a residue of the pyrolyzed biomass. The heat recovery device 20 shown in FIG. 3 is not provided in the embodiment of FIG. 4.

[0037] The pyrolysis chamber 1 and the medium regeneration chamber 44 are formed within the single fluidized-bed furnace 40. Specifically, an inside of the fluidized-bed furnace 40 is divided into the pyrolysis chamber 1 and the medium regeneration chamber 44 by a partition wall 45. The biomass as a raw material is supplied into the pyrolysis chamber 1 by a raw-material supply device (not shown). An overall shape of the fluidized-bed furnace 40 is not particularly limited, and may be, for example, cylindrical or rectangular.

[0038] A fluidized medium (e.g., silica sand) is contained in the pyrolysis chamber 1 and the medium regeneration chamber 44. A fluidizing gas is supplied into the pyrolysis chamber 1 and the medium regeneration chamber 44 to fluidize the fluidized medium.

The fluidizing gas supplied to the pyrolysis chamber 1 includes the reducing gas containing the hydrogen gas recovered by the gas separator 15 and fresh hydrogen gas supplied from the hydrogen-gas supply source 10. Specifically, the reducing gas containing the hydrogen gas recovered in the gas separator 15 is introduced to the pyrolysis chamber 1 through the reducing-gas transfer line 17 together with the fresh hydrogen gas, and serves as the fluidizing gas to fluidize the fluidized medium. Compressed air is supplied as the fluidizing gas to the medium regeneration chamber 44.

[0039] The biomass is fed into the pyrolysis chamber 1 while the fluidized medium circulates between the pyrolysis chamber 1 and the medium regeneration chamber 44.

The biomass is heated by the fluidized medium in the pyrolysis chamber 1 and pyrolyzed to generate the pyrolysis gas. A residue of the biomass is transported by the fluidized medium to the medium regeneration chamber 44. The biomass is combusted in the medium regeneration chamber 44 to heat the fluidized medium. The heated fluidized medium moves into the pyrolysis chamber 1 and functions as a heat source in the pyrolysis chamber 1. The fluidized-bed furnace 40, in which the fluidized medium circulates within the furnace in this manner, is an internal circulating fluidized-bed gasification system.

[0040] The pyrolysis treatment system further includes a solid-gas separator 50 configured to separate particles from the pyrolysis gas discharged from the pyrolysis chamber 1. Specific examples of particles removed by the solid-gas separator 50 include polymeric polymer and coke residue generated during pyrolysis of the biomass, fluidized medium (e.g., fine particles of silica sand), and fine particles of catalyst. An example of the solid-gas separator 50 is a cyclone-type solid-gas separator that separates particles from the pyrolysis gas by centrifugal force.

[0041] The solid-gas separator 50 is disposed between the pyrolysis chamber 1 and the hydrogenation reforming device 5, so that the pyrolysis gas discharged from the pyrolysis chamber 1 is delivered to the solid-gas separator 50. The particles removed by the solid-gas separator 50 are returned to the medium regeneration chamber 44. In one embodiment, the particles removed by the solid-gas separator 50 may be returned to the pyrolysis chamber 1. The particles in the pyrolysis gas are removed by the solid-gas separator 50, and as a result, the quality of the oil recovered in the oil reservoir 12 at the downstream side can be improved.

[0042] FIG. 5 is a block diagram showing an embodiment of a pyrolysis treatment system using the fluidized-bed furnace 40. Configuration and operation of this embodiment that will not be particularly described are the same as those of the embodiment described with reference to FIG. 4, and therefore duplicated descriptions will be omitted.

[0043] The pyrolysis treatment system of the embodiment shown in FIG. 5 further includes an oil-water separator 53 disposed between the condenser 7 and the oil reservoir

12. The oil-water mixture generated by the condenser 7 is delivered to the oil-water separator 53, which is configured to separate the oil from the water. The specific configuration of the oil-water separator 53 is not particularly limited. For example, a coalescer or a sedimentation tank can be used for the oil-water separator 53. The oil
5 separated by the oil-water separator 53 is delivered to the oil reservoir 12 and stored in the oil reservoir 12. The water separated from the oil by the oil-water separator 53 is drained from the oil-water separator 53.

[0044] FIG. 6 is a block diagram showing another embodiment of a pyrolysis treatment system using the fluidized-bed furnace 40. Configuration and operation of this
10 embodiment that will not be particularly described are the same as those of the embodiment described with reference to FIG. 5, and therefore duplicated descriptions will be omitted.

[0045] The pyrolysis treatment system of the embodiment shown in FIG. 6 further includes a cleaning device 55 disposed between the condenser 7 and the gas separator 15. The cleaning device 55 is configured to scrub the light gas with a scrubbing liquid by
15 bringing the scrubbing liquid into contact with the light gas passing through an inside of the cleaning device 55. A liquid, such as water, can be used as the scrubbing liquid. The specific configuration of the cleaning device 55 used is not particularly limited, and a known cleaning device, such as a scrubber, can be used. For example, a cleaning tower that includes a tower having a gas passage formed therein and a spray nozzle for spraying
20 water onto the gas flowing through the gas passage can be used as the cleaning device 55.

[0046] The light gas discharged from the condenser 7 is introduced into the cleaning device 55. The hydrogen, the hydrogen sulfide, and the ammonia discharged from the distillation tower 28 are also delivered to the cleaning device 55. Water-soluble substances, such as fine particles and ammonia, are removed from the light gas by the
25 cleaning device 55. The light gas that has passed through the cleaning device 55 is delivered to the gas separator 15.

[0047] FIG. 7 is a block diagram showing yet another embodiment of a pyrolysis treatment system utilizing the fluidized-bed furnace 40. Configuration and operation of

this embodiment that will not be particularly described are the same as those of the embodiment described with reference to FIG. 6, and therefore duplicated descriptions will be omitted.

[0048] In the embodiment shown in FIG. 7, a combination of an oil scrubber 60 and a
5 water scrubber 56 is used as the condenser 7. Specifically, the oil scrubber 60 and the water scrubber 56 as the condenser 7 are configured to cool the hydrogenated pyrolysis gas in two stages to condense oil component and moisture. The oil scrubber 60 is disposed downstream of the hydrogenation reforming device 5. The oil scrubber 60 is coupled to the hydrogenation reforming device 5, the water scrubber 56, and the oil reservoir 12. The
10 pyrolysis gas hydrogenated by the hydrogenation reforming device 5 is introduced to the oil scrubber 60.

[0049] The oil scrubber 60 is configured to cool heavy oil recovered on its bottom, and then spray the heavy oil onto the pyrolysis gas to cool the pyrolysis gas and condense gaseous oil component contained in the pyrolysis gas. In one embodiment, oil supplied
15 from outside, instead of the recovered heavy oil, may be sprayed in the oil scrubber 60.

[0050] In one example, the pyrolysis gas is cooled to 150°C by the oil scrubber 60. Thus, oil component having a boiling point of 150°C or higher is condensed in the oil scrubber 60. The condensed oil and the sprayed oil are discharged from the oil scrubber 60 as heavy oil and stored in the oil reservoir 12. The specific configuration of the oil scrubber
20 60 is not particularly limited, and a known oil scrubber can be used. For example, a cleaning tower that includes a tower having a gas passage formed therein and a spray nozzle for spraying oil onto a gas flowing through the gas passage can be used as the oil scrubber 60.

[0051] The water scrubber 56 is disposed between the oil scrubber 60 and the gas
25 separator 15. The water scrubber 56 is further coupled to the oil-water separator 53. The water scrubber 56 is configured to bring water into contact with the pyrolysis gas that has passed through the oil scrubber 60, thereby further cooling the pyrolysis gas. In this embodiment, the water scrubber 56 is configured to bring alkaline water into contact with

the pyrolysis gas. The pyrolysis gas is cooled by the contact with the water (e.g., alkaline water in this embodiment). For example, the pyrolysis gas is cooled from 150°C to 40°C by the water scrubber 56. Thus, in the water scrubber 56, oil component and moisture having boiling points generally within a range of 150°C to 40°C are condensed. Oil-water mixture is discharged from the water scrubber 56 and delivered to the oil-water separator 53. The oil-water separator 53 is configured to separate oil (e.g., light oil of 40°C) from the alkaline water. The pyrolysis gas from which the oil component and moisture have been removed by the water scrubber 56 is delivered as a light gas to the gas separator 15.

[0052] According to this embodiment, the oil contained in the pyrolysis gas is recovered by the oil scrubber 60 and the water scrubber 56, so that fine particles and water-soluble substance gases in the pyrolysis gas are removed and an overall oil yield is improved.

[0053] The hydrocracker 25 and the distillation tower 28 shown in FIGS. 3 to 7 may be omitted. The embodiments described with reference to FIGS. 1 to 7 may be combined as appropriate. For example, the condenser 7 constituted of a combination of the oil scrubber 60 and the water scrubber 56 shown in FIG. 7 may be applied to the embodiments described with reference to FIGS. 1 to 3.

[0054] The previous description of embodiments is provided to enable a person skilled in the art to make and use the present invention. Moreover, various modifications to these embodiments will be readily apparent to those skilled in the art, and the generic principles and specific examples defined herein may be applied to other embodiments. Therefore, the present invention is not intended to be limited to the embodiments described herein but is to be accorded the widest scope as defined by limitation of the claims.

Industrial Applicability

[0055] The present invention is applicable to a pyrolysis treatment system and a pyrolysis treatment method for pyrolyzing an oxygen-containing treatment object, such as biomass or municipal waste, and recovering oil from the generated pyrolysis gas.

Reference Signs List

[0056]

	1	pyrolysis chamber
	5	hydrogenation reforming device
	7	condenser
	10	hydrogen-gas supply source
5	12	oil reservoir
	15	gas separator
	17	reducing-gas transfer line
	20	heat recovery device
	21	fuel line
10	25	hydrocracker
	28	distillation tower
	40	fluidized-bed furnace
	44	medium regeneration chamber
	45	partition wall
15	50	solid-gas separator
	53	oil-water separator
	55	cleaning device
	56	water scrubber
	60	oil scrubber
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CLAIMS

[Claim 1] A pyrolysis treatment system for treating a treatment object containing oxygen, comprising:

5 a pyrolysis chamber configured to generate pyrolysis gas by pyrolyzing the treatment object;

a hydrogenation reforming device configured to hydrogenate the pyrolysis gas; and

a condenser configured to condense oil component and moisture contained in the hydrotreated pyrolysis gas to recover oil and light gas separately.

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[Claim 2] The pyrolysis treatment system according to claim 1, further comprising:

a gas separator configured to recover a reducing gas from the light gas; and

a reducing-gas transfer line configured to transfer the reducing gas to at least one of the pyrolysis chamber and the hydrogenation reforming device.

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[Claim 3] The pyrolysis treatment system according to claim 2, wherein the pyrolysis chamber comprises a pyrolysis chamber of a fluidized-bed furnace,

the fluidized-bed furnace includes the pyrolysis chamber and a medium regeneration chamber through which a fluidized medium circulates, and

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the pyrolysis treatment system further comprises a fuel line configured to supply the light gas from which the reducing gas has been removed by the gas separator to the medium regeneration chamber.

[Claim 4] The pyrolysis treatment system according to claim 3, further comprising

25 a solid-gas separator disposed between the pyrolysis chamber and the hydrogenation reforming device, the solid-gas separator being configured to separate particles from the pyrolysis gas discharged from the pyrolysis chamber.

[Claim 5] The pyrolysis treatment system according to claim 2, further comprising:
a heat recovery device configured to supply heat to the pyrolysis chamber; and
a fuel line configured to supply, to the heat recovery device, the light gas from
which the reducing gas has been removed by the gas separator.

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[Claim 6] The pyrolysis treatment system according to claim 1, wherein the
condenser includes an oil scrubber and a water scrubber.

[Claim 7] The pyrolysis treatment system according to claim 6, further comprising
10 an oil-water separator configured to divide oil-water mixture, discharged from the water
scrubber, into oil and water.

[Claim 8] A pyrolysis treatment method for treating a treatment object containing
oxygen, comprising:

15 pyrolyzing the treatment object in a pyrolysis chamber to generate pyrolysis gas;
hydrogenating the pyrolysis gas by a hydrogenation reforming device; and
condensing oil component and moisture contained in the hydrogenated pyrolysis
gas by a condenser to recover oil and light gas separately.

20 [Claim 9] The pyrolysis treatment method according to claim 8, further comprising:
recovering a reducing gas from the light gas by a gas separator; and
transferring the reducing gas to at least one of the pyrolysis chamber and the
hydrogenation reforming device.

25 [Claim 10] The pyrolysis treatment method according to claim 9, wherein the
pyrolysis chamber comprises a pyrolysis chamber of a fluidized-bed furnace,
the fluidized-bed furnace includes the pyrolysis chamber and a medium
regeneration chamber through which a fluidized medium circulates, and

the pyrolysis treatment method further comprises supplying, to the medium regeneration chamber, the light gas from which the reducing gas has been removed by the gas separator.

5 [Claim 11] The pyrolysis treatment method according to claim 10, further comprising separating particles from the pyrolysis gas discharged from the pyrolysis chamber by a solid-gas separator disposed between the pyrolysis chamber and the hydrogenation reforming device.

10 [Claim 12] The pyrolysis treatment method according to claim 9, further comprising:
supplying the light gas from which the reducing gas has been removed by the gas separator to a heat recovery device to combust the light gas; and
supplying heat generated by the combustion of the light gas to the pyrolysis chamber.

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[Claim 13] The pyrolysis treatment method according to claim 8, wherein the condenser includes an oil scrubber and a water scrubber.

[Claim 14] The pyrolysis treatment method according to claim 13, further
20 comprising dividing oil-water mixture, discharged from the water scrubber, into oil and water.