is lowed in the gasification chamber.

Citation List

Patent Literature

[0007] Patent document 1: Japanese Patent No. 4243919

Patent document 2: Japanese laid-open patent publication No. 10-2543

Patent document 3: Japanese laid-open patent publication No. 2002-129169

Patent document 4: Japanese Patent No. 3611306

Summary

Technical Problem

[0008] Therefore, the present disclosure provides a pyrolysis apparatus and a pyrolysis method capable of increasing a yield of an intended pyrolysis product.

Solution to Problem

[0009] In an example, there is provided a pyrolysis apparatus for pyrolyzing a raw material in a fluidized bed formed of a fluidized medium, comprising: a fluidized-bed furnace; a first partition wall dividing inside of the fluidized-bed furnace into a pyrolysis chamber and a combustion chamber; a second partition wall dividing the combustion chamber into a main combustion chamber and a settling combustion chamber; a first gas diffuser, a second gas diffuser, and a third gas diffuser configured to supply a first fluidizing gas, a second fluidizing gas, and a third fluidizing gas to the pyrolysis chamber, the main combustion chamber, and the settling combustion chamber, respectively; a first raw-material supply device configured to supply a first raw material to the pyrolysis chamber with a first supply amount; a second raw-material supply device configured to supply a second raw material to the pyrolysis chamber with a second supply amount, the second raw material having a lower ratio of carbon to hydrogen and a lower ratio of carbon to oxygen than those of the first raw material; and an operation controller configured to independently control operations of the first raw-material supply device and the second raw-material supply device.

[0009a] In an aspect, there is provided a pyrolysis apparatus for pyrolyzing a raw

material in a fluidized bed formed of a fluidized medium, comprising:

a fluidized-bed furnace;

a first partition wall dividing inside of the fluidized-bed furnace into a pyrolysis chamber and a combustion chamber;

a second partition wall dividing the combustion chamber into a main combustion chamber and a settling combustion chamber;

a first gas diffuser, a second gas diffuser, and a third gas diffuser configured to supply a first fluidizing gas, a second fluidizing gas, and a third fluidizing gas to the pyrolysis chamber, the main combustion chamber, and the settling combustion chamber, respectively;

a first raw-material supply device configured to supply a first raw material to the pyrolysis chamber with a first supply amount;

a second raw-material supply device configured to supply a second raw material to the pyrolysis chamber with a second supply amount, the second raw material having a lower ratio of carbon to hydrogen and a lower ratio of carbon to oxygen than those of the first raw material; and

an operation controller configured to independently control operations of the first raw-material supply device and the second raw-material supply device, wherein the operation controller is configured to regulate a ratio of the first supply amount to the second supply amount based on a temperature in the main combustion chamber or a temperature in the settling combustion chamber.

[0010] In an example, the operation controller is configured to regulate a ratio of the

first supply amount to the second supply amount based on a temperature in the main combustion chamber or a temperature in the settling combustion chamber.

In an example, the pyrolysis apparatus further comprises: a third raw-material supply device configured to supply the first raw material to the main combustion chamber; and a fourth raw-material supply device configured to supply the second raw material to the main combustion chamber.

[0011] In an example, the operation controller is configured to control an operation of the third gas diffuser such that a temperature in the settling combustion chamber is within a predetermined temperature range.

In an example, the third gas diffuser includes: a wind box disposed under the settling combustion chamber; a fluidizing-gas supply line coupled to the wind box; a temperature regulator attached to the fluidizing-gas supply line; and a gas flow-rate regulating valve attached to the fluidizing-gas supply line, and the operation controller is configured to control an operation of at least one of the temperature regulator and the gas flow-rate regulating valve such that the temperature in the settling combustion chamber is within the predetermined temperature range.

[0012] In an example, the pyrolysis apparatus further comprises a heat recovery device configured to recover heat from a fluidized medium in the settling combustion chamber, wherein the operation controller is configured to control an operation of the heat recovery device such that a temperature in the settling combustion chamber is within a predetermined temperature range.

In an example, the heat recovery device includes: a heat transfer tube disposed in the settling combustion chamber; and a refrigerant flow-rate regulating valve configured to regulate a flow rate of a cooling medium flowing in the heat transfer tube, and the operation controller is configured to control an operation of the refrigerant flow-rate regulating valve such that the temperature in the settling combustion chamber is within the predetermined temperature range.

[0013] In an example, the third gas diffuser includes: a plurality of wind boxes

disposed under the settling combustion chamber; a plurality of fluidizing-gas supply lines coupled to the plurality of wind boxes, respectively; and a plurality of gas flow-rate regulating valves attached to the plurality of fluidizing-gas supply lines, respectively, and the operation controller is configured to control operations of the plurality of gas flow-rate regulating valves such that opening degrees of the plurality of gas flow-rate regulating valves are different from each other.

In an example, the first gas diffuser includes at least one first fluidizing-gas supply source configured to supply the first fluidizing gas to the pyrolysis chamber, and the first fluidizing-gas supply source includes at least one supply source configured to supply at least one of carbon monoxide gas, carbon dioxide gas, hydrogen gas, hydrocarbon gas, vapor, and nitrogen gas.

[0014] In an example, there is provided a pyrolysis apparatus for pyrolyzing a raw material in a fluidized bed formed of a fluidized medium, comprising: a fluidized-bed furnace; a first partition wall dividing inside of the fluidized-bed furnace into a pyrolysis chamber and a combustion chamber; a second partition wall dividing the combustion chamber into a main combustion chamber and a settling combustion chamber; a first gas diffuser, a second gas diffuser, and a third gas diffuser configured to supply a first fluidizing gas, a second fluidizing gas, and a third fluidizing gas to the pyrolysis chamber, the main combustion chamber, and the settling combustion chamber, respectively; a raw-material supply device configured to supply a raw material to the pyrolysis chamber; a settling-combustion-chamber thermometer configured to measure a temperature in the settling combustion chamber; and an operation controller configured to control the temperature in the settling combustion chamber.

[0014a] In another aspect, there is provided a pyrolysis method of pyrolyzing a raw material using a pyrolysis apparatus having a fluidized-bed furnace containing a fluidized medium therein, inside of the fluidized-bed furnace being divided into a pyrolysis chamber, a main combustion chamber, and a settling combustion chamber, said method comprising:

supplying a first fluidizing gas to the pyrolysis chamber to form a first fluidized bed in the pyrolysis chamber;

supplying a first raw material to the pyrolysis chamber with a first supply amount, while supplying a second raw material to the pyrolysis chamber with a second supply amount, the second raw material having a lower ratio of carbon to hydrogen and a lower ratio of carbon to oxygen than those of the first raw material;

pyrolyzing the first raw material and the second raw material in the pyrolysis chamber;

combusting a residue of the first raw material and a residue of the second raw material in the main combustion chamber, while supplying a second fluidizing gas to the main combustion chamber to form a second fluidized bed in the main combustion chamber; and

moving a fluidized medium from the main combustion chamber to the pyrolysis chamber through the settling combustion chamber, while supplying a third fluidizing gas to the settling combustion chamber to form a third fluidized bed in the settling combustion chamber; and

controlling a ratio of the first supply amount to the second supply amount based on a temperature in the main combustion chamber or a temperature in the settling combustion chamber.

[0015] In an example, the operation controller is configured to control an operation of the third gas diffuser such that a measured value of the temperature in the settling combustion chamber is within a predetermined temperature range.

In an example, the third gas diffuser includes: a wind box disposed under the settling combustion chamber; a fluidizing-gas supply line coupled to the wind box; a

temperature regulator attached to the fluidizing-gas supply line; and a gas flow-rate regulating valve attached to the fluidizing-gas supply line, and the operation controller is configured to control an operation of at least one of the temperature regulator and the gas flow-rate regulating valve such that the measured value of the temperature in the settling combustion chamber is within the predetermined temperature range.

[0016] In an example, the pyrolysis apparatus further comprises a heat recovery device configured to recover heat from a fluidized medium in the settling combustion chamber, wherein the operation controller is configured to control an operation of the heat recovery device such that a measured value of the temperature in the settling combustion chamber is within a predetermined temperature range.

In an example, the heat recovery device includes: a heat transfer tube disposed in the settling combustion chamber; and a refrigerant flow-rate regulating valve configured to regulate a flow rate of a cooling medium flowing in the heat transfer tube, and the operation controller is configured to control an operation of the refrigerant flow-rate regulating valve such that the measured value of the temperature in the settling combustion chamber is within the predetermined temperature range.

In an example, the third gas diffuser includes: a plurality of wind boxes disposed under the settling combustion chamber; a plurality of fluidizing-gas supply lines coupled to the plurality of wind boxes, respectively; and a plurality of gas flow-rate regulating valves attached to the plurality of fluidizing-gas supply lines, respectively, and the operation controller is configured to control operations of the plurality of gas flow-rate regulating valves such that opening degrees of the plurality of gas flow-rate regulating valves are different from each other.

In an example, the third gas diffuser includes a fluidizing-gas supply source configured to supply the third fluidizing gas to the settling combustion chamber, and the fluidizing-gas supply source includes at least one supply source configured to supply at least one of carbon monoxide gas, carbon dioxide gas, hydrogen gas, hydrocarbon gas, vapor, and nitrogen gas.

[0017] In an example, there is provided a pyrolysis method of pyrolyzing a raw material using a pyrolysis apparatus having a fluidized-bed furnace containing a fluidized medium therein, inside of the fluidized-bed furnace being divided into a pyrolysis chamber, a main combustion chamber, and a settling combustion chamber, said method comprising: supplying a first fluidizing gas to the pyrolysis chamber to form a first fluidized bed in the pyrolysis chamber; supplying a first raw material to the pyrolysis chamber with a first supply amount, while supplying a second raw material to the pyrolysis chamber with a second supply amount, the second raw material having a lower ratio of carbon to hydrogen and a lower ratio of carbon to oxygen than those of the first raw material; pyrolyzing the first raw material and the second raw material in the pyrolysis chamber; combusting a residue of the first raw material and a residue of the second raw material in the main combustion chamber, while supplying a second fluidizing gas to the main combustion chamber to form a second fluidized bed in the main combustion chamber; and moving a fluidized medium from the main combustion chamber to the pyrolysis chamber through the settling combustion chamber, while supplying a third fluidizing gas to the settling combustion chamber to form a third fluidized bed in the settling combustion chamber.

[0018] In an example, the pyrolysis method further comprises controlling a ratio of the first supply amount to the second supply amount based on a temperature in the main combustion chamber or a temperature in the settling combustion chamber.

In an example, the pyrolysis method further comprises supplying at least one of the first raw material and the second raw material to the main combustion chamber, while supplying the first raw material and the second raw material to the pyrolysis chamber.

In an example, the pyrolysis method further comprises regulating a temperature or a flow rate of the third fluidizing gas such that a temperature in the settling combustion chamber is within a predetermined temperature range.

[0019] In an example, a heat transfer tube through which a cooling medium flows is

disposed in the settling combustion chamber, and the pyrolysis method further comprises regulating a flow rate of the cooling medium such that a temperature in the settling combustion chamber is within a predetermined temperature range.

In an example, the third fluidizing gas is supplied into the settling combustion chamber at different flow rates from a plurality of wind boxes disposed under the settling combustion chamber to swirl the fluidized medium forming the third fluidized bed.

In an example, the first fluidizing gas contains at least one of carbon monoxide gas, carbon dioxide gas, hydrogen gas, hydrocarbon gas, vapor, and nitrogen gas.

[0020] In an example, there is provided a pyrolysis method of pyrolyzing a raw material using a pyrolysis apparatus having a fluidized-bed furnace containing a fluidized medium therein, inside of the fluidized-bed furnace being divided into a pyrolysis chamber, a main combustion chamber, and a settling combustion chamber, said method comprising: supplying a first fluidizing gas to the pyrolysis chamber to form a first fluidized bed in the pyrolysis chamber; supplying a raw material to the pyrolysis chamber; pyrolyzing the raw material in the pyrolysis chamber; combusting a residue of the raw material in the main combustion chamber, while supplying a second fluidizing gas to the main combustion chamber to form a second fluidized bed in the main combustion chamber; moving a fluidized medium from the main combustion chamber to the pyrolysis chamber through the settling combustion chamber, while supplying a third fluidizing gas to the settling combustion chamber to form a third fluidized bed in the settling combustion chamber; and controlling a temperature of the settling combustion chamber within a predetermined temperature range.

[0021] In an example, the pyrolysis method further comprises regulating a temperature or a flow rate of the third fluidizing gas such that the temperature in the settling combustion chamber is within the predetermined temperature range.

In an example, a heat transfer tube through which a cooling medium flows is

disposed in the settling combustion chamber, and the pyrolysis method further comprises regulating a flow rate of the cooling medium such that the temperature in the settling combustion chamber is within the predetermined temperature range.

In an example, the third fluidizing gas is supplied into the settling combustion chamber at different flow rates from a plurality of wind boxes disposed under the settling combustion chamber to swirl the fluidized medium forming the third fluidized bed.

Advantageous Effects of Invention

[0022] According to an example of the present disclosure, the first raw material having the high ratio of carbon to hydrogen (carbon/hydrogen ratio) and the high ratio of carbon to oxygen (carbon/oxygen ratio), and the second raw material having the lower ratios than those of the first raw material are supplied simultaneously into the pyrolysis chamber. A thermal energy generated from the residue of the first raw material can sufficiently heat the fluidized medium in the main combustion chamber. Therefore, an amount of heat that the residue of the second raw material should have in the main combustion chamber can be low. As a result, a yield of pyrolysis product from the second raw material is improved. The heated fluidized medium moves from the main combustion chamber to the pyrolysis chamber through the settling combustion chamber, and pyrolyzes the first raw material and the second raw material.

[0023] According to an example of the present disclosure, the temperature of the fluidized medium is regulated in advance, and the fluidized medium then moves to the pyrolysis chamber, so that a local high temperature region is not formed in the pyrolysis chamber. Therefore, the raw material is heated within an appropriate temperature range in the pyrolysis chamber, and as a result, the yield of the desired pyrolysis product (e.g., oil) can be improved.

Brief Description of Drawings

[0024]

[FIG. 1] FIG. 1 is a diagram showing an embodiment of a pyrolysis apparatus;

CLAIMS

[Claim 1] A pyrolysis apparatus for pyrolyzing a raw material in a fluidized bed formed of a fluidized medium, comprising:

a fluidized-bed furnace;

a first partition wall dividing inside of the fluidized-bed furnace into a pyrolysis chamber and a combustion chamber;

a second partition wall dividing the combustion chamber into a main combustion chamber and a settling combustion chamber;

a first gas diffuser, a second gas diffuser, and a third gas diffuser configured to supply a first fluidizing gas, a second fluidizing gas, and a third fluidizing gas to the pyrolysis chamber, the main combustion chamber, and the settling combustion chamber, respectively;

a first raw-material supply device configured to supply a first raw material to the pyrolysis chamber with a first supply amount;

a second raw-material supply device configured to supply a second raw material to the pyrolysis chamber with a second supply amount, the second raw material having a lower ratio of carbon to hydrogen and a lower ratio of carbon to oxygen than those of the first raw material; and

an operation controller configured to independently control operations of the first raw-material supply device and the second raw-material supply device,

wherein the operation controller is configured to regulate a ratio of the first supply amount to the second supply amount based on a temperature in the main combustion chamber or a temperature in the settling combustion chamber.

[Claim 2] The pyrolysis apparatus according to claim 1, further comprising: a third raw-material supply device configured to supply the first raw material to the main combustion chamber; and

a fourth raw-material supply device configured to supply the second raw material

to the main combustion chamber.

[Claim 3] The pyrolysis apparatus according to claim 1 or 2, wherein the operation controller is configured to control an operation of the third gas diffuser such that a temperature in the settling combustion chamber is within a predetermined temperature range.

[Claim 4] The pyrolysis apparatus according to claim 3, wherein

the third gas diffuser includes:

a wind box disposed under the settling combustion chamber;

a fluidizing-gas supply line coupled to the wind box;

a temperature regulator attached to the fluidizing-gas supply line; and

a gas flow-rate regulating valve attached to the fluidizing-gas supply line, and

the operation controller is configured to control an operation of at least one of the temperature regulator and the gas flow-rate regulating valve such that the temperature in the settling combustion chamber is within the predetermined temperature range.

[Claim 5] The pyrolysis apparatus according to claim 1 or 2, further comprising a heat recovery device configured to recover heat from a fluidized medium in the settling combustion chamber, wherein

the operation controller is configured to control an operation of the heat recovery device such that a temperature in the settling combustion chamber is within a predetermined temperature range.

[Claim 6] The pyrolysis apparatus according to claim 5, wherein

the heat recovery device includes:

a heat transfer tube disposed in the settling combustion chamber; and

a refrigerant flow-rate regulating valve configured to regulate a flow rate of a cooling medium flowing in the heat transfer tube, and

the operation controller is configured to control an operation of the refrigerant flow-rate regulating valve such that the temperature in the settling combustion chamber is within the predetermined temperature range.

[Claim 7] The pyrolysis apparatus according to claim 5 or 6, wherein

the third gas diffuser includes:

a plurality of wind boxes disposed under the settling combustion chamber;

a plurality of fluidizing-gas supply lines coupled to the plurality of wind boxes, respectively; and

a plurality of gas flow-rate regulating valves attached to the plurality of fluidizing-gas supply lines, respectively, and

the operation controller is configured to control operations of the plurality of gas flow-rate regulating valves such that opening degrees of the plurality of gas flow-rate regulating valves are different from each other.

[Claim 8] The pyrolysis apparatus according to any one of claims 1 to 7, wherein

the first gas diffuser includes at least one first fluidizing-gas supply source configured to supply the first fluidizing gas to the pyrolysis chamber, and

the first fluidizing-gas supply source includes at least one supply source configured to supply at least one of carbon monoxide gas, carbon dioxide gas, hydrogen gas, hydrocarbon gas, vapor, and nitrogen gas.

[Claim 9] A pyrolysis method of pyrolyzing a raw material using a pyrolysis apparatus having a fluidized-bed furnace containing a fluidized medium therein, inside of the fluidized-bed furnace being divided into a pyrolysis chamber, a main combustion

chamber, and a settling combustion chamber, said method comprising:

supplying a first fluidizing gas to the pyrolysis chamber to form a first fluidized bed in the pyrolysis chamber;

supplying a first raw material to the pyrolysis chamber with a first supply amount, while supplying a second raw material to the pyrolysis chamber with a second supply amount, the second raw material having a lower ratio of carbon to hydrogen and a lower ratio of carbon to oxygen than those of the first raw material;

pyrolyzing the first raw material and the second raw material in the pyrolysis chamber;

combusting a residue of the first raw material and a residue of the second raw material in the main combustion chamber, while supplying a second fluidizing gas to the main combustion chamber to form a second fluidized bed in the main combustion chamber; and

moving a fluidized medium from the main combustion chamber to the pyrolysis chamber through the settling combustion chamber, while supplying a third fluidizing gas to the settling combustion chamber to form a third fluidized bed in the settling combustion chamber; and

controlling a ratio of the first supply amount to the second supply amount based on a temperature in the main combustion chamber or a temperature in the settling combustion chamber.

[Claim 10] The pyrolysis method according to claim 9, further comprising supplying at least one of the first raw material and the second raw material to the main combustion chamber, while supplying the first raw material and the second raw material to the pyrolysis chamber.

[Claim 11] The pyrolysis method according to claim 9 or 10, further comprising regulating a temperature or a flow rate of the third fluidizing gas such that a temperature

in the settling combustion chamber is within a predetermined temperature range.

[Claim 12] The pyrolysis method according to claim 9 or 10, wherein

a heat transfer tube through which a cooling medium flows is disposed in the settling combustion chamber, and

the pyrolysis method further comprises regulating a flow rate of the cooling medium such that a temperature in the settling combustion chamber is within a predetermined temperature range.

[Claim 13] The pyrolysis method according to claim 12, wherein the third fluidizing gas is supplied into the settling combustion chamber at different flow rates from a plurality of wind boxes disposed under the settling combustion chamber to swirl the fluidized medium forming the third fluidized bed.

[Claim 14] The pyrolysis method according to any one of claims 9 to 13, wherein the first fluidizing gas contains at least one of carbon monoxide gas, carbon dioxide gas, hydrogen gas, hydrocarbon gas, vapor, and nitrogen gas.