

DESCRIPTION

Title of Invention

COMBUSTION DEVICE, BOILER, COMBUSTION METHOD

Technical Field

[0001]

The present invention relates to a combustion device and a boiler that combust a fuel.

Background Art

[0002]

A bubbling fluidized bed (BFB) boiler or a circulating fluidized bed (CFB) boiler that combusts a fuel with a fluidized layer or a fluidized bed formed by a fluid material such as silica sand fluidized in a combustion chamber as a medium is known as a boiler that generates vapor from water with heat generated by the combustion of the fuel. PTL 1 discloses the CFB boiler.

Citation List

Patent Literature

[0003]

[PTL 1] Japanese Unexamined Patent Publication No.

2012-255612

Summary of Invention

Technical Problem

[0004]

Since the BFB boiler or the CFB boiler can realize high combustion efficiency with a high-temperature fluid material fluidized in the combustion chamber as a medium, the BFB boiler or the CFB boiler is suitable for combustion of an unstable quality fuel such as biomass (biofuel), sludge (slurry), and a waste material (waste paper, waste plastic, waste tires, or the like) or a flame-retardant fuel. However, since all the fuels have carbon as a main component, a greenhouse gas such as carbon dioxide is generated during combustion, and there is a possibility in which global warming aggravates further. With recent movement for decarbonization, in the long term, demand for biomass fuels, which can be said to be carbon-neutral, has increased, and it is difficult to stably procure biomass fuels with stable quality at low costs. In the BFB boiler and the CFB boiler of which main objects are combustion of coal or a flame-retardant carbon containing fuel such as a waste fuel, a response to combustion methods that do not exhaust a greenhouse gas such as carbon dioxide is a problem in addition to use of biomass fuels.

[0005]

The present invention is devised in view of such circumstances, and an object thereof is to provide a combustion device and a boiler that can reduce generation of greenhouse gases.

Solution to Problem

[0006]

According to an aspect of the present invention, in order to solve the problem, there is provided a combustion device that supplies a fuel into a combustion chamber in which a fluid material is fluidized and that combusts the fuel, the device including a carbon-free fuel supply unit that supplies a carbon-free fuel which does not contain carbon into the combustion chamber.

[0007]

According to another aspect of the present invention, there is provided a boiler. The boiler includes a combustion section that supplies a fuel into a combustion chamber in which a fluid material is fluidized and that combusts the fuel, a carbon-free fuel supply unit that supplies a carbon-free fuel which does not contain carbon into the combustion chamber, and a vapor generation section that generates vapor from water with heat generated by the combustion section.

[0008]

Any combination of the components described above and substitutions of expressions of the present invention between methods, devices, systems, recording media, computer programs, and the like can also be effective as aspects of the present invention.

Advantageous Effects of Invention

[0009]

With the present invention, generation of greenhouse gases can be reduced by supplying the carbon-free fuel.

Brief Description of Drawings

[0010]

Fig. 1 shows an overall configuration of a circulating fluidized bed boiler (CFB boiler).

Fig. 2 schematically shows a configuration example of a start-up burner that is a hybrid fuel supply unit.

Description of Embodiments

[0011]

Hereinafter, an embodiment for carrying out the present invention will be described in detail with reference to the drawings. In the description and drawings, the same or equivalent components, members, and processing will be assigned with the same reference symbols, and

redundant descriptions thereof will be omitted as appropriate. The scales and shapes of shown parts are set for convenience in order to make the description easy to understand and are not to be understood as limiting unless stated otherwise. The embodiment is merely an example and does not limit the scope of the present invention. All characteristics and combinations to be described in the embodiment are not necessarily essential to the invention.

[0012]

A combustion device of the present invention is any device that supplies a fuel into a combustion chamber in which a fluid material is fluidized and that combusts the fuel. For example, in a case where the combustion device is configured as a boiler, the combustion device can be configured as a BFB boiler or a CFB boiler that combusts a fuel with a fluidized layer or a fluidized bed formed by a fluid material such as silica sand fluidized in the combustion chamber as a medium. In the present embodiment, an example in which the combustion device is configured as the CFB boiler will be mainly described.

[0013]

Fig. 1 shows an overall configuration of the circulating fluidized bed boiler (CFB boiler) that is the combustion device. The CFB boiler includes a combustion section 1 that supplies a fuel into a furnace 11 in which a

fluid material such as silica sand is fluidized and that combusts the fuel, a vapor generation section 2 that generates vapor from water with heat generated by the combustion section 1, a fluid material circulation section 3 that collects the fluid material which has come out of the furnace 11 and that returns the fluid material into the furnace 11, a heat transfer section 4 that heats air supplied to the combustion section 1, water supplied to the vapor generation section 2, and vapor generated by the vapor generation section 2 with a high-temperature exhaust gas of the combustion section 1, a dust collection device 5 that separates and collects soot or dust in the exhaust gas from the heat transfer section 4, and a chimney 6 that discharges the exhaust gas cleaned by the dust collection device 5 to the atmosphere.

[0014]

The combustion section 1 includes the furnace 11 which is the combustion chamber. The furnace 11 has a tubular shape that is long in a vertical direction and has a tapered bottom portion in order to increase the density of a solid fuel or a fluid material to enable efficient combustion. The bottom portion of the furnace 11 may not have a tapered shape, and the furnace 11 may be formed to have a substantially constant tubular sectional shape from a top portion to the bottom portion. A region of the bottom

portion of the furnace 11 shown by A shows a fluidized layer (also called a fluidized bed or a sand layer) formed by a high-density fluid material. In a fluidized layer A, a fluid material in the form of powder or particles such as silica sand is fluidized by air which is a fluidizing fluid supplied from the bottom portion of the furnace 11. A fuel input into the fluidized layer A efficiently combusts by repeatedly coming into contact with a high-temperature fluid material and air to be agitated therein.

[0015]

Since a fluid material rises in the furnace 11 due to an upward airflow generated by combustion, the fluid material is also present in a free board B that is a space above the fluidized layer A. The density of the fluid material in the free board B is lower than the density of the fluid material in the fluidized layer A and decreases toward an upper side of the furnace 11. In the free board B, a fuel that has not completely combusted in the fluidized layer A combusts while coming into contact with a floating fluid material. Although silica sand has been given as an example of the fluid material, any fluid material may be used insofar as the fluid material functions as a medium transferring heat to a fuel while maintaining a solid state without combustion even in the high-temperature furnace 11 and being fluidized and may be,

for example, other types of sand, stones such as limestone, and ash.

[0016]

At the bottom portion of the furnace 11, a perforated plate (also called a dispersion plate) 121 that is a fluid permeation portion configured by a porous material through which a fluid containing air permeates is provided. An air box 122 that is a space immediately below the perforated plate 121 configures a fluidizing fluid supply unit (air supply unit) that supplies pressurized air supplied from a first blower 71, which is an air blower, via a first flow rate control valve 71A into the furnace 11 via the perforated plate 121. The pressurized air supplied to the bottom portion of the furnace 11 by the air box 122 fluidizes a fluid material to form the fluidized layer A and is used in combustion of a fuel in the fluidized layer A or the free board B. In order to promote combustion of the fuel in the free board B and to suppress generation of harmful substances such as dioxin and carbon monoxide caused by incomplete combustion, a second blower 72 that is an air blower supplies pressurized air into the free board B via a second flow rate control valve 72A. Although the fluid permeation portion has been described with the perforated plate 121 given as an example in the present embodiment, the fluid permeation portion is not limited to

the present embodiment insofar as a fluid material can be fluidized in the fluidized layer A, or may be formed of, for example, multiple plates in which a slit for supplying a fluidizing fluid into the furnace 11 is formed.

[0017]

In order to circulate a fluid material in the fluidized layer A, an external circulation mechanism 13 that includes a circulation path outside the furnace 11 is provided. The external circulation mechanism 13 includes an extraction pipe 131 that communicates with the bottom portion of the furnace 11 and that can extract some of the fluid material in the fluidized layer A, an opening and closing valve 132 that controls opening and closing of the extraction pipe 131 and that can regulate a flow rate of the fluid material, that is, an amount of the fluid material extracted by the extraction pipe 131, a fluid material conveyor 133 such as a bucket conveyor that transports the fluid material extracted by the extraction pipe 131 upward, a fluid material silo 134 that is provided at an outer periphery of the furnace 11, which corresponds to an upper portion of the fluidized layer A, and that receives the fluid material transported by the fluid material conveyor 133, and a fluid material reinput portion 135 that reinputs the fluid material stored in the fluid material silo 134 into the furnace 11.

[0018]

The extraction pipe 131, the opening and closing valve 132, the fluid material conveyor 133, the fluid material silo 134, and the fluid material reinput portion 135 configure the circulation path for the fluid material, that connects a space between a bottom surface and a side surface of the furnace 11 to the outside of the furnace 11. That is, the fluid material extracted from the bottom surface of the furnace 11 by the extraction pipe 131 is reinput from the side surface of the furnace 11 by the fluid material reinput portion 135 into the fluidized layer A via the opening and closing valve 132, the fluid material conveyor 133, and the fluid material silo 134.

[0019]

At a furnace wall which is a side wall of the furnace 11, a fluid material supply unit 14 that supplies a fluid material for forming the fluidized layer A into the furnace 11 when the CFB boiler is started up and a solid fuel supply unit 15 that supplies a solid fuel to be combusted mainly in the fluidized layer A into the furnace 11 are provided. The fluid material supply unit 14 includes a funnel-shaped fluid material hopper 141 that stores the fluid material and a fluid material feeder 142 that supplies the fluid material discharged from a bottom portion of the fluid material hopper 141 into the furnace

11. By controlling the rotation speed of the fluid material feeder 142, a predetermined amount of the fluid material is input into the furnace 11. The solid fuel supply unit 15 includes a funnel-shaped solid fuel hopper 151 that stores the solid fuel and a solid fuel feeder 152 that supplies the solid fuel discharged from a bottom portion of the solid fuel hopper 151 into the furnace 11. By controlling the rotation speed of the solid fuel feeder 152, a predetermined amount of the solid fuel is input into the furnace 11.

[0020]

A solid fuel supplied by the solid fuel supply unit 15 into the furnace 11 is not particularly limited, and examples thereof include various types of coal, such as smokeless coal, bitumen coal, and brown coal, biomass, sludge, and a waste material. In the CFB boiler, since high combustion efficiency can be realized with a high-temperature fluid material fluidized in the furnace 11 as a medium, a low-quality fuel or a flame-retardant fuel can also efficiently combust. The solid fuel mentioned above is a carbon containing fuel that contains carbon, and the solid fuel supply unit 15 configures a carbon containing fuel supply unit that supplies the carbon containing fuel into the furnace 11. In addition, although there are currently few specific examples, in a case where a solid

fuel that does not contain carbon is available, the solid fuel supply unit 15 that supplies such a carbon-free fuel into the furnace 11 configures a carbon-free fuel supply unit.

[0021]

In addition to or instead of the solid fuel supply unit 15, a carbon-free fuel supply unit 16 that supplies a non-solid or fluid (liquid or gas) carbon-free fuel into the furnace 11 is provided at each part of the combustion section 1. Hereinafter, four provision examples of the carbon-free fuel supply unit 16 will be shown, but a provision location or a provision mode of the carbon-free fuel supply unit 16 is not limited thereto. The number of carbon-free fuel supply units 16 is not limited to four as well, and at least one carbon-free fuel supply unit 16 achieves an effect of the present embodiment such as suppression of greenhouse gas generation to be described later. The carbon-free fuel supply units 16 may be provided at five or more locations. In addition, in the following description, ammonia is used as an example of a non-solid carbon-free fuel, but other fuels such as hydrogen may be used.

[0022]

A carbon-free fuel supply unit 16A according to a first provision mode supplies ammonia, which is a carbon-

free fuel, to the air box 122. In a state of being mixed with pressurized air supplied from the first blower 71 into the air box 122, the ammonia supplied to the air box 122 permeates the perforated plate 121 and is supplied into the fluidized layer A from below. By supplying the ammonia that is a non-solid fuel together with the pressurized air that agitates a fluid material and a solid fuel in the fluidized layer A, the fluid material, the solid fuel, the pressurized air, and the ammonia are mixed with each other, so that ammonia known to be flame-retardant can be efficiently combusted. The carbon-free fuel supply unit 16A includes a storage unit 161A that stores ammonia in a non-solid state such as a gas and a liquid and a jetting device 162A that jets the ammonia stored in the storage unit 161A in a non-solid state such as a gas and a liquid into the air box 122.

[0023]

A carbon-free fuel supply unit 16B according to a second provision mode supplies ammonia that is a carbon-free fuel from the side of the fluidized layer A (a fluid material of the bottom portion of the furnace 11) above the perforated plate 121 into the fluidized layer A. The ammonia directly supplied into the fluidized layer A is efficiently combusted by being mixed with the fluid material, a solid fuel, and pressurized air in the

fluidized layer A. The carbon-free fuel supply unit 16B includes a storage unit 161B that stores ammonia in a non-solid state such as a gas and a liquid and a jetting device 162B that jets the ammonia stored in the storage unit 161B in a non-solid state such as a gas and a liquid into the fluidized layer A. Herein, as a tip part of the jetting device 162B is provided to be inserted from the side into the fluidized layer A, the ammonia can be efficiently jetted into the fluidized layer A. The jetting device 162B may be configured as a burner that mixes the ammonia with air and that combusts the mixture, or a tip of the jetting device 162B in this case, which is a crater of the burner, jets flame caused by the combustion of the ammonia into the fluidized layer A. Such a burner that is the carbon-free fuel supply unit 16B can be configured as, for example, a lance burner or a burner lance, and the carbon-free fuel such as ammonia is combusted on the side of the fluid material of the bottom portion of the furnace 11 (that is, the fluidized layer A).

[0024]

A position of a jetting port that is the tip of the jetting device 162B of the carbon-free fuel supply unit 16B may be any position insofar as the jetting port faces the fluidized layer A. For example, since a typical height of the fluidized layer A is approximately 1.5 m in a case

where a height of the furnace 11 is approximately 30 m, a height of the jetting port of the jetting device 162B is preferably less than approximately 1.5 m from the bottom surface of the furnace 11 or is specifically 0.5 m or the like. In addition, when expressed as a percentage with respect to the height of the furnace 11, 1.5 m, which is the typical height of the fluidized layer A, corresponds to 5.0% of 30 m, while the height of the jetting port of the jetting device 162B is preferably within a range of 1.0% to 4.0% and more preferably within a range of 1.5% to 2.5% (0.5 m above corresponds to 1.7% of 30 m).

[0025]

In addition, by providing the position of the jetting port that is the tip of the jetting device 162B of the carbon-free fuel supply unit 16B configured by the burner or the like at a height less than 1.5 m from the bottom surface of the furnace 11, an effect in which generation and exhaustion of nitrous oxide (N_2O : also called as dinitrogen oxide or dinitrogen monoxide) caused by combustion of ammonia can be reduced is confirmed. It is considered that this is because nitrous oxide generated near the position of the jetting port of the carbon-free fuel supply unit 16B is reduced and converted back to nitrogen while passing through a main combustion region thereabove. In order to increase a reducing effect caused

by such reduction of nitrous oxide, the position of the jetting port of the carbon-free fuel supply unit 16B may be further lowered, for example, is preferably at a height less than 1.0 m from the bottom surface of the furnace 11, and is more preferably at a height less than 0.5 m from the bottom surface of the furnace 11.

[0026]

Similarly, by providing the position of the jetting port that is the tip of the jetting device 162B of the carbon-free fuel supply unit 16B configured by the burner or the like at a height that is equal to or larger than 1.5 m (preferably equal to or smaller than an upper surface of the fluidized layer A) from the bottom surface of the furnace 11, an effect in which generation and exhaustion of nitrogen oxide (NO_x) caused by combustion of ammonia can be reduced is confirmed. It is considered that this is because the nitrogen oxide generated at the bottom portion of the furnace 11 reacts to ammonia supplied by the burner or the like and is reduced to nitrogen. Since a reduction effect of the nitrogen oxide is obtained while maintaining complete combustion of the supplied ammonia, the jetting port of the carbon-free fuel supply unit 16B is preferably provided below a supply port (pressurized air is supplied above the fluidized layer A in Fig. 1, but the pressurized air may be supplied from the side of the fluidized layer A

in reality) for pressurized air from the second blower 72 provided typically at a height of approximately 3.0 m to 4.0 m from the bottom surface of the furnace 11. In order to simultaneously obtain such complete combustion of the ammonia and such a reduction effect of the nitrogen oxide, the jetting port of the carbon-free fuel supply unit 16B may be provided below the supply port for the pressurized air, and the jetting port of the carbon-free fuel supply unit 16B may be at, for example, a height of 2.0 m or more from the bottom surface of the furnace 11 or may be at a height of 3.0 m or more from the bottom surface of the furnace 11, for example, with respect to the typical pressurized air supply port above (at a height of approximately 3.0 m to 4.0 m).

[0027]

In order to effectively reduce exhaustion of N_2O and NO_x , the burner that is the carbon-free fuel supply unit 16B at a height of less than 1.5 m (or less than 1.0 m, less than 0.5 m) and the burner that is the carbon-free fuel supply unit 16B at a height of 1.5 m or more (or 2.0 m or more, 3.0 m or more) are preferably established side by side. By individually adjusting a supply amount or a combustion amount of a carbon-free fuel such as ammonia at each burner, exhaust amounts of N_2O and NO_x in the furnace 11 can be minimized or optimized.

[0028]

A carbon-free fuel supply unit 16C according to a third provision mode is configured integrally with a start-up burner to be described later and supplies ammonia, which is a carbon-free fuel, from above the fluidized layer A downward toward a surface (upper surface) of the fluidized layer A. The ammonia supplied from the carbon-free fuel supply unit 16C is mixed with a fluid material, a solid fuel, and pressurized air fluidized on the surface of the fluidized layer A and is efficiently combusted. Herein, by a combination of at least two of the carbon-free fuel supply unit 16A that supplies ammonia from below the fluidized layer A, the carbon-free fuel supply unit 16B that supplies ammonia from the side of the fluidized layer A, and the carbon-free fuel supply unit 16C that supplies ammonia from above the fluidized layer A, the ammonia can be jetted to the fluid material, the solid fuel, and the pressurized air fluidized at each part of the fluidized layer A from different directions and be efficiently mixed, so that ammonia known to be flame-retardant can be efficiently combusted at each part of the fluidized layer A.

[0029]

The carbon-free fuel supply unit 16C includes a storage unit 161C that stores ammonia in a non-solid state

such as a gas and a liquid and a jetting device 162C that jets the ammonia stored in the storage unit 161C in a non-solid state such as a gas and a liquid into the furnace 11. Herein, the jetting device 162C also functions as a start-up burner to be described later and is provided to be inclined downward to be capable of directly heating the surface of the fluidized layer A with flame jetted from a tip thereof. Although a specific configuration will be described later, the CFB boiler is generally provided with a start-up burner for start-up, and the existing start-up burner can also be used as the carbon-free fuel supply unit 16C for ammonia supply in the present embodiment.

[0030]

A position of the jetting port that is the tip of the jetting device 162C of the carbon-free fuel supply unit 16C is determined by a position of the existing start-up burner. For example, a typical height of the start-up burner is approximately 2.0 m in a case where the height of the furnace 11 is approximately 30 m and is positioned above the fluidized layer A having a height of approximately 1.5 m. The carbon-free fuel supply unit 16C may be provided separately from the start-up burner, or the height of the jetting port of the jetting device 162C in this case can be freely set. For example, it is preferable that the jetting port of the jetting device 162C is

provided at a height of 6.0% or more (1.8 m or more) of the height of the furnace 11 such that ammonia can be effectively jetted to the surface of the fluidized layer A at a height of 5.0% (1.5 m) of the height (30 m) of the furnace 11. In a case where a downward inclination angle of the jetting device 162C is large, the ammonia can be jetted to the surface of the fluidized layer A even when a provision height is large.

[0031]

A carbon-free fuel supply unit 16D according to a fourth provision mode supplies ammonia, which is a carbon-free fuel, into the free board B, which is an upper portion of the furnace 11. The ammonia supplied into the free board B combusts unburned substances derived from a solid fuel or the like which has not been completely combusted in the fluidized layer A, suppressing generation of harmful substances such as dioxin and carbon monoxide caused by incomplete combustion. In particular, it is important to maintain the temperature at approximately 800°C or more in order not to generate dioxin in the free board B, and a high temperature of approximately 800°C or more can be maintained also in the free board B separated from the fluidized layer A where main combustion occurs by combusting ammonia from the carbon-free fuel supply unit 16D.

[0032]

In addition, ammonia functions also as a reducer, and nitrogen oxide (NOx) that is an air pollutant which can occur by combustion in the furnace 11 is reduced into harmless nitrogen and water. As an exhaust gas after combustion at a lower portion of the furnace 11 supplies the ammonia from the carbon-free fuel supply unit 16D to the free board B before coming out of the furnace 11, the nitrogen oxide in the exhaust gas can be effectively removed.

[0033]

The carbon-free fuel supply unit 16D includes a storage unit 161D that stores ammonia in a non-solid state such as a gas and a liquid and a jetting device 162D that jets the ammonia stored in the storage unit 161D in a non-solid state such as a gas and a liquid into the free board B. The jetting device 162D may be configured as a burner that mixes the ammonia with air and that combusts the mixture, or a tip of the jetting device 162D in this case, which is a crater of the burner, jets flame caused by the combustion of the ammonia into the free board B.

[0034]

The position of a jetting port that is the tip of the jetting device 162D of the carbon-free fuel supply unit 16D may be any position insofar as the jetting port faces the

free board B. For example, in a case where the height of the furnace 11 is approximately 30 m, an upper side of the fluidized layer A, which is at approximately 1.5 m, configures the free board B. However, since a fluid material or a solid fuel in the form of powder or particles combusts while moving vigorously at a portion close to the surface of the fluidized layer A, the jetting port of the jetting device 162D is preferably separated sufficiently from the surface of the fluidized layer A in order to achieve the effect of removing dioxin or nitrogen oxide. On the other hand, when the position of the jetting port of the jetting device 162D is excessively high, an exhaust gas before dioxin or nitrogen oxide is sufficiently removed by ammonia comes out of the furnace 11, which is not preferable. In consideration of these points, the height of the jetting port of the jetting device 162D is preferably within, for example, a range of 50% (15 m) to 70% (21m) of the height of the furnace 11 (30 m).

[0035]

As described above, by providing the carbon-free fuel supply units 16A to 16D at a plurality of different positions in a vertical direction that is a height direction of the furnace 11, combustion spots of ammonia known to be flame-retardant are dispersed, so that high combustion efficiency can be realized as a whole. In

addition, by adopting a configuration where the ammonia is combusted little by little at each part of the furnace 11 as described above, a supply amount of the ammonia can be increased as a whole while maintaining high combustion efficiency. In other words, a large amount of a carbon containing fuel of the related art, such as coal of which a main component is carbon, can be replaced with a carbon-free fuel such as ammonia and hydrogen. Since the carbon-free fuel does not generate a greenhouse gas containing carbon such as carbon dioxide during combustion, an adverse effect on the global environment where warming progresses can be reduced.

[0036]

Next, the start-up burner configured integrally with the carbon-free fuel supply unit 16C (written as a start-up burner 16C) will be described. The start-up burner 16C is provided with a carbon containing fuel storage unit 163C that stores heavy oil, which is a carbon containing fuel, in parallel with the carbon-free fuel storage unit 161C that stores ammonia, which is a carbon-free fuel. A carbon-free fuel control valve 164C that controls a supply amount of the ammonia from the carbon-free fuel storage unit 161C to the jetting device 162C is provided between the carbon-free fuel storage unit 161C and the jetting device 162C, and a carbon containing fuel control valve 165C that

controls a supply amount of the heavy oil from the carbon containing fuel storage unit 163C to the jetting device 162C is provided between the carbon containing fuel storage unit 163C and the jetting device 162C.

[0037]

A mode switching unit 166C controls the carbon-free fuel control valve 164C and the carbon containing fuel control valve 165C and complementarily switches open and closed states thereof. In a first mode in which the carbon-free fuel control valve 164C is in an open state and the carbon containing fuel control valve 165C is in a closed state, the jetting device 162C supplies ammonia from the carbon-free fuel storage unit 161C into the furnace 11. In a second mode in which the carbon-free fuel control valve 164C is in a closed state and the carbon containing fuel control valve 165C is in an open state, the jetting device 162C supplies heavy oil from the carbon containing fuel storage unit 163C into the furnace 11. Specifically, the heavy oil mixed with air is combusted in the jetting device 162C configured as a burner, and the tip of the jetting device 162C, which is a crater of the burner, jets flame caused by the combustion of the heavy oil into the furnace 11.

[0038]

The mode switching unit 166C switches to the second mode when the CFB boiler is started up and switches to the first mode after the start-up of the CFB boiler. When the CFB boiler is started up, a fluid material such as silica sand for forming the fluidized layer A is supplied from the fluid material supply unit 14 into the furnace 11. In this case, a solid fuel such as coal may be supplied from the solid fuel supply unit 15 together into the furnace 11, or a carbon-free fuel such as ammonia and hydrogen may be supplied from the carbon-free fuel supply units 16A, 16B, and 16D, excluding the carbon-free fuel supply unit 16C, together into the furnace 11. The jetting device 162C that operates in the second mode when the CFB boiler is started up heats the fluid material supplied from the fluid material supply unit 14 with flame caused by combustion of heavy oil. Herein, since the jetting device 162C is provided to be inclined downward, the surface of the fluidized layer A formed by the fluid material is directly heated, and temperatures of the fluidized layer A and the inside of the furnace 11 efficiently increase. In this manner, the start-up burner 16C is also called an on-sand burner since the sand-like fluidized layer A is heated from above.

After the CFB boiler, in which the temperatures of the fluidized layer A and the inside of the furnace 11 have sufficiently increased, is started up, that is, after combustion of a solid fuel in the fluidized layer A has become possible, the mode switching unit 166C switches to the first mode. The jetting device 162C that operates in the first mode jets a carbon-free fuel such as ammonia and hydrogen from the tip thereof to the surface of the fluidized layer A. As described above, the start-up burner 16C is a hybrid fuel supply unit that functions as a carbon containing fuel supply unit supplying heavy oil, which is a carbon containing fuel, in the second mode during the start-up and that functions as a carbon-free fuel supply unit supplying ammonia, hydrogen, or the like, which is a carbon-free fuel, in the first mode after the start-up. The start-up burner of the related art stops after the temperatures have been increased with heavy oil or the like during the start-up, but the start-up burner according to the present embodiment can be effectively used as a carbon-free fuel supply unit even after the start-up.

[0040]

Fig. 2 schematically shows a configuration example of the start-up burner 16C that is the hybrid fuel supply unit. The jetting device 162C of the start-up burner 16C includes a carbon-free fuel receiving unit 167C that

receives ammonia which is a carbon-free fuel from the carbon-free fuel storage unit 161C and a carbon containing fuel receiving unit 168C that receives heavy oil which is a carbon containing fuel from the carbon containing fuel storage unit 163C.

[0041]

The combustion section 1 of the CFB boiler has been described in detail hereinbefore. Next, a configuration other than the combustion section 1 of the CFB boiler will be described. The vapor generation section 2 includes a drum 21 that stores water for generating vapor, a water supply pipe 22 through which water is supplied to the drum 21, a water pipe 23 through which the water in the drum 21 is introduced into the high-temperature furnace 11 and is heated, and a vapor pipe 24 through which vapor generated from the water heated in the water pipe 23 is exhausted from the drum 21 as an output of the CFB boiler. The water supply pipe 22 configures a coal economizer that preheats water supply by meandering in the heat transfer section 4 through which a high-temperature exhaust gas of the combustion section 1 passes, and the vapor pipe 24 configures a superheater that superheats vapor by meandering in the heat transfer section 4 through which the high-temperature exhaust gas of the combustion section 1 passes. Similarly, pressurized air supplied into the

furnace 11 by the first blower 71 and the second blower 72 is also preheated with the high-temperature exhaust gas in the heat transfer section 4.

[0042]

The fluid material circulation section 3 includes a cyclone 31 that separates and collects a fluid material from an exhaust gas exhausted from the upper portion of the furnace 11 and a seal pot 32 that returns the fluid material collected by the cyclone 31 into the furnace 11. The cyclone 31 is a cyclone-type powder separator that has a substantially cylindrical upper portion and a substantially conical lower portion and generates an airflow that spirally descends along an inner wall. The fluid material contained in the exhaust gas from the furnace 11 is collected by coming into contact with the inner wall of the cyclone 31 and falling when descending spirally along the airflow. The exhaust gas contains not only the fluid material but also ammonia supplied from the carbon-free fuel supply units 16A to 16D. For this reason, even when nitrogen oxide remains in the exhaust gas, the nitrogen oxide can be efficiently removed by the ammonia moving vigorously in the cyclone 31. Further, complete combustion of the ammonia that is an unburned combustible can be expected by promoting contact between the carbon-free fuel ammonia, which is an unburned combustible

remaining in the exhaust gas in the cyclone 31, and the fluid material, in other words, as the cyclone 31 functions as an ammonia mixer or a carbon-free fuel agitating unit. From a perspective of causing the cyclone 31 to function as the ammonia mixer, it is preferable that the carbon-free fuel supply units 16A to 16D are provided on an upstream side of the cyclone 31 in an exhaust gas flow.

[0043]

The seal pot 32 provided below the cyclone 31 is filled with a fluid material, and backflow of an unburned gas or the like from the furnace 11 to the cyclone 31 is prevented. The fluid material filling the seal pot 32 gradually returns into the furnace 11 in the form of being pushed out by the weight of a fluid material newly collected by the cyclone 31.

[0044]

The present invention has been described hereinbefore based on the embodiment. It is clear for those skilled in the art that the embodiment is an example, various modification examples are possible for a combination of each component and each processing process, and such modification examples are also within the scope of the present invention.

[0045]

Although the CFB boiler has been described as an example of the boiler in the embodiment, the present invention can also be applied to a bubbling fluidized bed boiler (BFB boiler). The configuration of the BFB boiler is the same as the CFB boiler except that the fluid material circulation section 3 that collects a fluid material which has come out of the furnace 11 and that returns the fluid material into the furnace 11 is not included.

[0046]

A functional configuration of each device described in the embodiment can be realized by a hardware resource or a software resource, or by cooperation of the hardware resource and the software resource. A processor, a ROM, a RAM, or other LSI can be used as the hardware resource. A program such as an operating system and an application can be used as the software resource.

Industrial Applicability

[0047]

The present invention relates to the combustion device and the boiler that combust a fuel.

Reference Signs List

[0048]

1 combustion section

2 vapor generation section
3 fluid material circulation section
4 heat transfer section
11 furnace
13 external circulation mechanism
14 fluid material supply unit
15 solid fuel supply unit
16 carbon-free fuel supply unit
16C start-up burner
31 cyclone
32 seal pot
121 perforated plate
122 air box
166C mode switching unit
167C carbon-free fuel receiving unit
168C carbon containing fuel receiving unit

CLAIMS

1. A combustion device that supplies a fuel into a combustion chamber in which a fluid material is fluidized and that combusts the fuel, the device comprising:

a carbon-free fuel supply unit that supplies a carbon-free fuel which does not contain carbon into the combustion chamber.

2. The combustion device according to claim 1, further comprising:

a carbon containing fuel supply unit that supplies a carbon containing fuel which contains carbon into the combustion chamber.

3. The combustion device according to claim 2, wherein the carbon-free fuel supply unit and the carbon containing fuel supply unit are configured as an integral hybrid fuel supply unit, and

the hybrid fuel supply unit includes a carbon-free fuel receiving unit that receives the carbon-free fuel and a carbon containing fuel receiving unit that receives the carbon containing fuel.

4. The combustion device according to claim 3,

wherein the hybrid fuel supply unit further includes a mode switching unit that switches between a first mode in which the carbon-free fuel is supplied into the combustion chamber and a second mode in which the carbon containing fuel is supplied into the combustion chamber.

5. The combustion device according to claim 4,

wherein the mode switching unit switches to the second mode when the combustion device is started up and switches to the first mode after the start-up of the combustion device.

6. The combustion device according to any one of claims 1 to 5, further comprising:

a fluid permeation portion that is provided at a bottom portion of the combustion chamber and through which a fluid permeates; and

a fluidizing fluid supply unit that supplies air which fluidizes the fluid material into the combustion chamber via the fluid permeation portion,

wherein the carbon-free fuel supply unit supplies the carbon-free fuel to the fluid material on the fluid permeation portion and supplies the carbon-free fuel, which is the fluid, together with the air into the combustion chamber via the fluid permeation portion.

7. The combustion device according to any one of claims 1 to 5,

wherein the carbon-free fuel supply unit supplies the carbon-free fuel from a side to the fluid material of a bottom portion of the combustion chamber.

8. The combustion device according to claim 7,

wherein the carbon-free fuel supply unit is a burner that combusts the carbon-free fuel on a side of the fluid material of the bottom portion of the combustion chamber.

9. The combustion device according to claim 8,

wherein the burner is provided at a height of less than 1.5 m from a bottom surface of the combustion chamber.

10. The combustion device according to claim 8,

wherein the burner is provided at a height of 1.5 m or more from a bottom surface of the combustion chamber.

11. The combustion device according to any one of claims 1 to 5,

wherein the carbon-free fuel supply unit supplies the carbon-free fuel to a plurality of positions having different heights in the combustion chamber.

12. The combustion device according to any one of claims 1 to 5,

wherein the carbon-free fuel is a non-solid fuel.

13. The combustion device according to claim 12,

wherein the non-solid fuel is at least one of ammonia and hydrogen.

14. The combustion device according to any one of claims 1 to 5, further comprising:

a fluid material circulation section that collects the fluid material which has come out of the combustion chamber and that returns the fluid material into the combustion chamber.

15. The combustion device according to any one of claims 1 to 5,

wherein the combustion device is a circulating fluidized bed boiler.

16. A boiler comprising:

a combustion section that supplies a fuel into a combustion chamber in which a fluid material is fluidized and that combusts the fuel;

a carbon-free fuel supply unit that supplies a carbon-free fuel which does not contain carbon into the combustion chamber; and

a vapor generation section that generates vapor from water with heat generated by the combustion section.

17. A combustion method of supplying a fuel into a combustion chamber in which a fluid material is fluidized and combusting the fuel, the method comprising:

a carbon-free fuel supply step of supplying a carbon-free fuel that does not contain carbon into the combustion chamber.