

DESCRIPTION

Title of Invention

COMBUSTION DEVICE, COMBUSTION METHOD, AND MEMORY MEDIUM

Technical Field

[0001]

The present disclosure relates to a combustion device and the like.

Background Art

[0002]

As a boiler (combustion device) that generates vapor from water using heat produced by fuel combustion, a bubbling fluidized bed (BFB) boiler and a circulating fluidized bed (CFB) boiler are known, in which fuel is burned via a fluidized layer or fluidized bed formed by a fluidizing medium such as silica sand fluidized within a combustion chamber. PTL 1 discloses a CFB boiler.

Citation List

Patent Literature

[0003]

[PTL 1] Japanese Unexamined Patent Application

Publication No. 2012-255612

Summary of Invention

Technical Problem

[0004]

The combustion device in the related art has often used fossil fuels such as coal as fuel; however, in recent years, with heightened environmental awareness, the use of biomass fuels and the like, which impose a smaller environmental burden than fossil fuels, has also been increasing. A representative example of the biomass fuel is a woody pellet derived from wood. Since the woody pellet has a property of expanding when containing moisture, it is preferable to use the woody pellet in a dry state. However, since the woody pellet in a dry state may generate a large amount of powder when being charged into the combustion chamber, it is necessary to take safety measures in view of possible ignition of the powder due to heat in the combustion chamber.

[0005]

The present disclosure has been made in view of the above-described circumstances, and an object of the present disclosure is to provide a combustion device and the like capable of effectively preventing excessive combustion of fuel in a fuel supply unit.

Solution to Problem

[0006]

In order to achieve the above-described object, an aspect of the present disclosure relates to a combustion device that charges a fuel into a combustion chamber to burn the fuel, the combustion device including: a fuel supply unit including a fuel feed port through which the fuel is supplied and a fuel charging port through which the fuel is charged into the combustion chamber; and an opening/closing unit that opens and closes the fuel feed port in accordance with a state quantity between the fuel feed port and the fuel charging port.

[0007]

According to the present aspect, since combustion of the fuel in the fuel supply unit, or a sign thereof, is effectively detected based on the state quantity, expansion of the combustion can be prevented in advance by closing the fuel feed port with the opening/closing unit.

[0008]

Another aspect of the present disclosure relates to a combustion method. This method is a combustion method of charging a fuel into a combustion chamber to burn the fuel, the combustion method including: opening and closing a fuel feed port through which the fuel is supplied, in accordance with a state quantity between the fuel feed port and a fuel

charging port through which the fuel is charged into the combustion chamber.

[0009]

Still another aspect of the present disclosure relates to a storage medium. This storage medium stores a combustion program for charging a fuel into a combustion chamber to burn the fuel and causing a computer to execute: opening and closing a fuel feed port through which the fuel is supplied, in accordance with a state quantity between the fuel feed port and a fuel charging port through which the fuel is charged into the combustion chamber.

[0010]

Any combination of the above-described components, and any implementation obtained by converting these expressions into a method, a device, a system, a recording medium, a computer program, or the like, is also encompassed by the present disclosure.

Advantageous Effects of Invention

[0011]

According to the present disclosure, it is possible to effectively prevent excessive combustion of the fuel in the fuel supply unit.

Brief Description of Drawings

[0012]

FIG. 1 schematically illustrates a CFB boiler.

FIG. 2 schematically illustrates details of a fuel supply unit.

FIG. 3 schematically illustrates a presumed time-dependent change in each state quantity when combustible powder derived from a woody pellet is ignited in a feeder by heat in a furnace.

Description of Embodiments

[0013]

Hereinafter, a form for embodying the present disclosure (hereinafter, also referred to as an embodiment) will be described in detail with reference to the accompanying drawings. In the description and/or the drawings, the same reference signs are assigned to the same or equivalent components, members, processes, and the like, and repeated descriptions thereof are omitted. The scale and shape of each unit illustrated in the drawings are set for convenience to simplify the description, and are not to be construed as limiting unless otherwise specifically stated. The embodiment is illustrative and does not limit the scope of the present disclosure in any way. All the features and combinations thereof presented in the embodiment are not necessarily essential to the present disclosure. For

convenience, the embodiment is presented by decomposing the embodiment into components for each function and/or for each function group implementing the embodiment. However, one component in the embodiment may actually be implemented by a combination of a plurality of separate components, and a plurality of components in the embodiment may actually be implemented by a single integrated component.

[0014]

FIG. 1 schematically illustrates a circulating fluidized bed (CFB) boiler as a combustion device according to the present embodiment. Instead of the CFB boiler, any other combustion device such as a bubbling fluidized bed (BFB) boiler or a rotary kiln may be used. Any other type of boiler, such as a reheater boiler or a once-through boiler, may also be used as the combustion device according to the present disclosure.

[0015]

The CFB boiler includes a combustion section 1 in which a fuel such as a biomass fuel or a fossil fuel such as coal is supplied into and burned in a furnace 11 in which a fluidizing medium such as silica sand is fluidized, a vapor generation section 2 that generates vapor from water by heat generated in the combustion section 1, a fluidizing medium circulation section 3 as a circulation section that collects a fluidizing medium flowing out of the furnace 11 and returns

the fluidizing medium into the furnace 11, a heat transfer section 4 that heats the water supplied to the vapor generation section 2 or the vapor generated in the vapor generation section 2 with a high-temperature exhaust gas of the combustion section 1, an exhaust gas treatment device 5 that separates and collects soot and dust in exhaust gas from the heat transfer section 4, and a stack 6 that releases the exhaust gas purified by the exhaust gas treatment device 5 into the atmosphere.

[0016]

The combustion section 1 includes the furnace 11 as a combustion chamber. The furnace 11 has a long tubular shape in a vertical direction, and a bottom thereof has a tapered shape to increase the density of a solid fuel such as a biomass fuel or coal or a fluidizing medium and to enable efficient combustion. The bottom of the furnace 11 may not have a tapered shape, and the furnace 11 may be formed in a tubular shape having a substantially constant cross-sectional shape from the top to the bottom. A region indicated by "A" in the bottom of the furnace 11 indicates a fluidized bed (also referred to as a fluidized bed or a sand layer) formed by a high-density fluidizing medium. In the fluidized bed A, the fluidizing medium such as silica sand in a powder form, a particle form, or a lump form is fluidized by a fluidizing fluid supplied from the bottom of the furnace 11. The solid

fuel such as the biomass fuel or the coal charged into the fluidized bed A is efficiently burned by being repeatedly brought into contact with a high-temperature fluidizing medium to be stirred in the fluidized bed A.

[0017]

Since the fluidizing medium rises in the furnace 11 due to ascending airflow caused by combustion, the fluidizing medium is also present in a freeboard B, which is a space above the fluidized bed A. The density of the fluidizing medium in the freeboard B is lower than the density of the fluidizing medium in the fluidized bed A, and is reduced toward an upper side of the furnace 11. In the freeboard B, the fuel that has not been completely burned in the fluidized bed A is burned while coming into contact with a floating fluidizing medium. Although silica sand has been described as an example of the fluidizing medium, any fluidizing medium that can function as a medium for transferring heat to the fuel while remaining in a solid state and flowing without being burned even in the high-temperature furnace 11 may be used, for example, other types of sand, stones such as limestone, or ash.

[0018]

A porous plate 121 (also referred to as a distributor plate) is provided at the bottom of the furnace 11 as a fluid-permeable portion formed of a porous material that allows the

fluidizing fluid such as air to pass therethrough. A wind box 122, which is a space directly below the porous plate 121, constitutes a fluidizing fluid supply unit that supplies, into the furnace 11 through the porous plate 121, pressurized air or the like as a fluidizing fluid supplied from a first blower 71 via a first flow rate control valve 71A. The fluidizing fluid supplied to the bottom of the furnace 11 by the wind box 122 fluidizes the fluidizing medium to form the fluidized bed A, and is used for the combustion of the fuel in the fluidized bed A or the freeboard B. Although the porous plate 121 is exemplified as the fluid-permeable portion in FIG. 1, the fluid-permeable portion may be any portion that allows the fluidizing medium to flow in the fluidized bed A, and may be formed of, for example, a large number of plates in which slits for supplying the fluidizing fluid into the furnace 11 are formed.

[0019]

A second blower 72 provided in addition to the first blower 71 supplies pressurized air or the like into the freeboard B via a second flow control valve 72A to promote the combustion of the fuel in the freeboard B and to suppress the generation of harmful substances, such as dioxin and carbon monoxide, due to incomplete combustion.

[0020]

On a bottom side of the furnace 11, there may be provided an extraction pipe 131 that communicates with the bottom and is capable of extracting a portion of the fluidizing medium in the fluidized bed A, and an on-off valve 132 that controls opening/closing of the extraction pipe 131 to adjust a flow rate of the fluidizing medium, that is, an amount of the fluidizing medium extracted by the extraction pipe 131.

[0021]

A furnace wall, which is a side wall of the furnace 11, is provided with a fuel supply unit 14 that supplies fuel into the furnace 11, a fluidizing medium supply unit 15 that supplies fluidizing medium for forming the fluidized bed A into the furnace 11, and a startup unit 16 that starts up the CFB boiler. Although details will be described later, the fuel supply unit 14 includes a fuel storage unit 141 that stores fuel, a pulverizing unit 142 that pulverizes the fuel discharged from the bottom of the fuel storage unit 141 into granules, and a feeder 143 that feeds the fuel pulverized by the pulverizing unit 142 into the furnace 11. The bottom shape of the fuel storage unit 141 is arbitrary, and may be, for example, a flat bottom shape or a funnel shape. Hereinafter, the fuel supply unit 14 will be described as supplying the solid fuel, but may supply a fluid fuel such

as a liquid or gaseous biomass fuel, oil, ammonia, or hydrogen in addition to or instead of the solid fuel.

[0022]

The fuel supply unit 14 supplies any fuel such as fossil fuels, such as coal, biomass fuels, sludge, or waste materials into the furnace 11. In particular, the biomass fuel is a carbon-neutral fuel having a small or zero net carbon dioxide emission amount (however, since the biomass fuel contains carbon, carbon dioxide is generated during combustion). In order to reduce an amount of carbon dioxide generated in the furnace 11, the fuel supply unit 14 may supply, into the furnace 11, a carbon-free fuel that does not contain carbon, in addition to a carbon-containing fuel such as the biomass fuel.

[0023]

The pulverizing unit 142 in the fuel supply unit 14 pulverizes the solid fuel into granules before being charged into the furnace 11. Since the size of the solid fuel suitable for transport to the CFB boiler or the fuel storage unit 141 may differ from the size of the solid fuel suitable for combustion in the furnace 11, the pulverizing unit 142 pulverizes the solid fuel into particles having a particle size suitable for the latter. When the particle size suitable for each solid fuel is different, the pulverizing unit 142 may be provided for each solid fuel, or the particle size

when each solid fuel is pulverized in order by one pulverizing unit 142 may be changed for each solid fuel. When the solid fuel having a particle size stored in the fuel storage unit 141 can be fed into the furnace 11 as it is without any problem, the pulverizing unit 142 may not be provided.

[0024]

Here, the terms such as "particle", "granular", and "particle size" do not specify a specific size or dimension, and the size or dimension is arbitrary as long as the solid fuel supplied into the furnace 11 can achieve desired combustion. For example, the terms such as "lump", "lump shape", and "lump diameter" used for relatively large particles, and the terms such as "powder", "powdery", and "powder diameter" used for relatively small particles are included in "particle", "granular", and "particle size" in the present embodiment. The granular solid fuel pulverized by the pulverizing unit 142 is charged into the furnace 11 through the feeder 143 in a required amount. The amount of the solid fuel charged into the furnace 11 may be controlled in accordance with the rotation speed of a conveyor or a rotary feeder (not illustrated) provided between the fuel storage unit 141 and a rotary valve 144 described later, or may be controlled in accordance with the rotation speed of the feeder 143 configured by a screw conveyor or the like.

[0025]

The fluidizing medium supply unit 15, which supplies the fluidizing medium for forming the fluidized bed A, includes a funnel-shaped fluidizing medium hopper 151 that stores a fluidizing medium, and a fluidizing medium feeder 152 that supplies a fluidizing medium exhausted from the bottom of the fluidizing medium hopper 151 into the furnace 11. The rotation speed of the fluidizing medium feeder 152 is controlled, so that a required amount of the fluidizing medium is charged into the furnace 11.

[0026]

The startup unit 16 that starts up the CFB boiler includes a startup fuel storage unit 161, a startup fuel control valve 162, and a startup burner 163. The startup fuel storage unit 161 stores, for example, heavy oil. The startup fuel control valve 162 controls the amount of the heavy oil to be supplied from the startup fuel storage unit 161 to the startup burner 163. Specifically, when the CFB boiler is started up, the startup fuel control valve 162 is brought into an opened state and supplies the heavy oil stored in the startup fuel storage unit 161 to the startup burner 163. The startup burner 163 heats the fluidizing medium in the fluidized bed A by a flame generated by the combustion of the heavy oil supplied from the startup fuel control valve 162. Since the startup burner 163 is provided to be inclined downward, the surface of the fluidized bed A formed by the

fluidizing medium is directly heated, and thus the temperatures in the fluidized bed A and the furnace 11 efficiently rise. Such a startup burner 163 is also referred to as a sand-top burner as it heats the sand-like fluidized bed A from above.

[0027]

After the CFB boiler is started up and the temperature of the fluidized bed A and the inside of the furnace 11 is sufficiently raised, specifically, after the fuel supplied from the fuel supply unit 14 can be burned in the fluidized bed A, the startup fuel control valve 162 is switched to a closed state to stop the supply of the heavy oil to the startup burner 163. In a subsequent normal operation state, the fuel supplied from the fuel supply unit 14 is burned in the high-temperature furnace 11.

[0028]

The combustion section 1 of the CFB boiler has been described above in detail. Subsequently, the configurations 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 to be used to generate 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 guided 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. A vapor turbine of a generator 25 is rotated by the vapor output from the vapor pipe 24 to generate electricity. The water supply pipe 22 constitutes an economizer that meanders in the heat transfer section 4 through which the high-temperature exhaust gas of the combustion section 1 passes and preheats supplied water, and the vapor pipe 24 constitutes a superheater that meanders in the heat transfer section 4 through which the high-temperature exhaust gas of the combustion section 1 passes, and that superheats the vapor. Similarly, the pressurized air or the like supplied into the furnace 11 by the first blower 71 and the second blower 72 is also preheated by the high-temperature exhaust gas in the heat transfer section 4.

[0029]

The fluidizing medium circulation section 3 includes a cyclone 31 that separates and collects the granular fluidizing medium from the exhaust gas exhausted from the upper portion of the furnace 11, and a circulation seal 32 (also called a wall seal or a seal pot) that returns the fluidizing medium collected by the cyclone 31 into the furnace 11. The cyclone 31 is a cyclone-type powder separator having an upper portion formed in a substantially cylindrical shape and a lower portion formed in a substantially conical shape, and generates an airflow that spirally descends along an

inner wall. The granular fluidizing medium contained in exhaust gas from the furnace 11 is collected by contacting the inner wall of the cyclone 31 and falling down while spirally descending along the airflow.

[0030]

Since the circulation seal 32 provided below the cyclone 31 is filled with the fluidizing medium (not illustrated), the backflow of unburned gas or the like from the furnace 11 to the cyclone 31 is prevented. The granular fluidizing medium filled in the circulation seal 32 gradually returns into the furnace 11 while being pushed out by the weight of a fluidizing medium newly collected by the cyclone 31. The fluidizing medium passing through the circulation seal 32 may be mixed with combustion ash such as the biomass fuel burned in the furnace 11.

[0031]

FIG. 2 schematically illustrates details of the fuel supply unit 14 according to the present embodiment. As described above, the fuel supply unit 14 includes the fuel storage unit 141 and the feeder 143 that charges the fuel into the furnace 11. In the example of this drawing, the pulverizing unit 142 in FIG. 1 is omitted. The fuel supply unit 14 includes a fuel feed port 14I through which the fuel stored in the fuel storage unit 141 is supplied, and a fuel charging port 140 through which the fuel is charged into the

furnace 11. The fuel stored in the fuel storage unit 141 is supplied to the fuel feed port 14I via the rotary valve 144. The supply amount or supply speed of the fuel to the fuel feed port 14I is appropriately adjusted through control of a rotation speed of a rotor in a conveyor or the rotary valve 144 (not illustrated).

[0032]

The fuel feed port 14I is provided with an automatic gate valve 7A and a manual gate valve 7M as an opening/closing unit that can open and close the fuel feed port 14I. As will be described later, the automatic gate valve 7A can automatically open and close the fuel feed port 14I, and the manual gate valve 7M can manually open and close the fuel feed port 14I. Except for exceptional cases described below, as a general rule, while the fuel is being charged into the furnace 11 through the fuel charging port 140, the automatic gate valve 7A and the manual gate valve 7M are open, and a required amount of the fuel is supplied continuously or intermittently through the fuel feed port 14I in an open state.

[0033]

The feeder 143 constitutes a solid fuel transport unit that transports the solid fuel such as the biomass fuel supplied from the fuel feed port 14I to the fuel charging port 140. The feeder 143 is configured, for example, by a

screw conveyor. It is preferable that the feeder 143 is inclined downward toward the fuel charging port 140 such that the solid fuel supplied from the fuel feed port 14I and mechanically transported by the screw conveyor or the like is naturally guided to the fuel charging port 140 by its dead weight. The rotation speed of the screw conveyor or the like may be constant, or may be variable such that the amount of the solid fuel charged into the furnace 11 can be controlled.

[0034]

As described above, the fuel supply unit 14 according to the present embodiment can be used to supply various fuels into the furnace 11, but is particularly suitable for the biomass fuel that has attracted attention as a carbon-neutral fuel. For example, the fuel supply unit 14 according to the present embodiment may be used to supply a representative woody pellet as the solid biomass fuel into the furnace 11.

[0035]

Since the woody pellet has a property of expanding when containing moisture, it is preferable that the woody pellet is supplied from the fuel feed port 14I in a dry state. Such a woody pellet in a dry state may generate a large amount of a combustible or flammable powder (hereinafter, also referred to as a combustible powder) derived from wood when falling from the fuel feed port 14I to the feeder 143, when being mechanically transported by the feeder 143 such as a screw

conveyor, when being charged from the fuel charging port 140 into the furnace 11, or the like. Since such a combustible powder is easily ignited by the heat in the furnace 11, the combustible powder is effective for promoting the combustion in the furnace 11, but it is not preferable that the ignited combustible powder flows back into the fuel supply unit 14.

[0036]

In order to prevent such a backflow of the combustible powder, in the present embodiment, a fluid flow unit 9 that causes the fluid to flow toward the fuel charging port 140 in the fuel supply unit 14 is provided. The fluid may be, for example, any gas that does not hinder the desired combustion of the fuel in the furnace 11, but is air in the present embodiment. The fluid flow unit 9 includes a fluid supply pipe 91 to which the fluid such as air is supplied, a first branch pipe 92 that branches from the fluid supply pipe 91 and is connected downstream of the fuel feed port 14I in the fuel supply unit 14, and a second branch pipe 93 that branches from the fluid supply pipe 91 and is connected upstream (for example, the rotary valve 144) of the fuel feed port 14I in the fuel supply unit 14.

[0037]

The first branch pipe 92 causes air to flow to the right in FIG. 2, for example, immediately downstream of the fuel feed port 14I and immediately upstream of the feeder 143.

The second branch pipe 93 causes air to flow in a fuel supply direction (downward in FIG. 2) at the fuel feed port 14I through the rotary valve 144. The air from the first branch pipe 92 and the second branch pipe 93 merges immediately downstream of the automatic gate valve 7A and the manual gate valve 7M provided at the fuel feed port 14I. Specifically, a rightward airflow from the first branch pipe 92 merges with a downward airflow from the second branch pipe 93, and an airflow toward the feeder 143 and the fuel charging port 140 is formed.

[0038]

The fluid flow unit 9 as described above causes air to steadily flow from the fuel charging port 140 into the furnace 11. Therefore, the backflow of the combustible powder derived from the woody pellet charged from the fuel charging port 140 into the furnace 11 into the feeder 143 is effectively prevented.

[0039]

In the present embodiment, at least one state quantity acquisition unit that acquires a state quantity representing a state in the fuel supply unit 14 between the fuel feed port 14I and the fuel charging port 140 is provided. In the example of FIG. 2, three types of state quantity acquisition units are schematically illustrated.

[0040]

A first state quantity acquisition unit is a temperature sensor 81 that measures a temperature in the fuel supply unit 14. The temperature sensor 81 may measure, for example, a temperature in the feeder 143, or may measure a temperature of an outer surface of the feeder 143 made of a material having a high thermal conductivity such as iron.

[0041]

A second state quantity acquisition unit is a pressure sensor 82 that measures a pressure of a fluid such as air flowing in the fuel supply unit 14 through the fluid flow unit 9. The pressure sensor 82 may measure, for example, a pressure of air passing through any of the pipes 91 to 93 (preferably, the first branch pipe 92 as illustrated) in the fluid flow unit 9, or may measure a pressure of air in the fuel supply unit 14.

[0042]

A third state quantity acquisition unit is a flow rate sensor 83 that measures a flow rate of a fluid such as air flowing in the fuel supply unit 14 through the fluid flow unit 9. The flow rate sensor 83 may measure, for example, a flow rate of air passing through any of the pipes 91 to 93 (preferably, the fluid supply pipe 91 as illustrated) in the fluid flow unit 9, or may measure a flow rate of air in the fuel supply unit 14.

[0043]

The automatic gate valve 7A as the opening/closing unit opens and closes the fuel feed port 14I in accordance with at least one state quantity acquired by various state quantity acquisition units as described above. Specifically, the automatic gate valve 7A opens the fuel feed port 14I when each state quantity acquired by each state quantity acquisition unit is within a predetermined allowable range, and closes the fuel feed port 14I when each state quantity is out of the allowable range.

[0044]

When the temperature in the fuel supply unit 14 measured by the temperature sensor 81 is used as the state quantity, the automatic gate valve 7A opens the fuel feed port 14I when the temperature is equal to or lower than a predetermined upper limit temperature, and closes the fuel feed port 14I when the temperature exceeds the upper limit temperature. When the temperature in the fuel supply unit 14 exceeds the upper limit temperature, the combustible powder derived from the woody pellet ignited by the heat in the furnace 11 may flow back into the feeder 143, and thus the temperature may rapidly increase. As a result, in order to prevent the further spread of fire to the woody pellet in the fuel supply unit 14 or the fuel storage unit 141, the automatic gate valve 7A is closed to forcibly cut off the supply of the fuel through the fuel feed port 14I.

[0045]

When the pressure of the air measured by the pressure sensor 82 is used as the state quantity, the automatic gate valve 7A opens the fuel feed port 14I when the pressure is equal to or lower than a predetermined upper limit pressure, and closes the fuel feed port 14I when the pressure exceeds the upper limit pressure. When the pressure of the air flowing in the fuel supply unit 14 through the fluid flow unit 9 exceeds the upper limit pressure, the combustible powder derived from the woody pellet ignited by the heat in the furnace 11 may flow back into the feeder 143, and thus the pressure may rapidly increase. As a result, in order to prevent the further spread of fire to the woody pellet in the fuel supply unit 14 or the fuel storage unit 141, the automatic gate valve 7A is closed to forcibly cut off the supply of the fuel through the fuel feed port 14I.

[0046]

When the flow rate of the air measured by the flow rate sensor 83 is used as the state quantity, the automatic gate valve 7A opens the fuel feed port 14I when the flow rate is equal to or higher than a predetermined lower limit flow rate, and closes the fuel feed port 14I when the flow rate is lower than the lower limit flow rate. When the flow rate of the air flowing in the fuel supply unit 14 through the fluid flow unit 9 is lower than the lower limit flow rate, the

combustible powder derived from the woody pellet ignited by the heat in the furnace 11 may flow back into the feeder 143, and thus the pressure of the air in the fuel supply unit 14 may rapidly increase (or the air may rapidly expand), and the inflow of the additional air from the fluid flow unit 9 may be hindered, resulting in a rapid decrease in the flow rate. As a result, in order to prevent the further spread of fire to the woody pellet in the fuel supply unit 14 or the fuel storage unit 141, the automatic gate valve 7A is closed to forcibly cut off the supply of the fuel through the fuel feed port 14I. The lower limit flow rate may be determined as a maximum decrease amount from the measured flow rate by the flow rate sensor 83 when the fuel supply unit 14 is normally operated.

[0047]

FIG. 3 schematically illustrates a time-dependent change in each state quantity when the combustible powder derived from the woody pellet is ignited in the feeder 143 by the heat in the furnace 11. In this drawing, a horizontal axis represents time, and a vertical axis represents each state quantity (therefore, an absolute value on the vertical axis does not have a special meaning).

[0048]

As illustrated in this drawing, the influence of backflow of the ignited combustible powder is considered to

initially manifest in the form of a sudden increase in air pressure measured by the pressure sensor 82 and/or a sudden decrease in an air flow rate measured by the flow rate sensor 83. Therefore, it is possible to quickly detect the risk of the backflow of the ignited combustible powder and quickly close the automatic gate valve 7A by using the pressure sensor 82 and/or the flow rate sensor 83.

[0049]

On the other hand, an increase in the temperature in the fuel supply unit 14 measured by the temperature sensor 81 is considered to be more gradual than changes in the air pressure and/or the air flow rate, and to appear later in time. However, since the air pressure and/or the air flow rate may greatly fluctuate and become unstable, there is significance in using the temperature in the fuel supply unit 14, which is a more stable indicator than these.

[0050]

As illustrated in FIG. 2, in the fuel supply unit 14 according to the present embodiment, the incombustible-fluid supply unit 84 may supply the incombustible fluid into the fuel supply unit 14 in addition to or instead of the automatic opening and closing of the fuel feed port 14I by the automatic gate valve 7A described above. Specifically, when each state quantity acquired by each of the state quantity acquisition units 81 to 83 is outside the allowable range as described

above, the incombustible-fluid supply unit 84 supplies the incombustible fluid such as vapor, nitrogen, and exhaust gas of the combustion section 1 into the fuel supply unit 14. Even when the combustible powder derived from the woody pellet ignited by the heat in the furnace 11 flows back into the feeder 143, the incombustible fluid is quickly digested or extinguished, so that the further spread of fire to the woody pellet in the fuel supply unit 14 or the fuel storage unit 141 is prevented in advance.

[0051]

The present disclosure has been described above based on the embodiment. Various modifications are possible for combinations of the components and processes in the illustrative embodiments, and it will be apparent to those skilled in the art that such modifications are included within the scope of the present disclosure.

[0052]

The configurations, operations, and functions of the respective devices and methods described in the embodiments can be implemented by hardware resources or software resources, or by cooperation of hardware resources and software resources. As hardware resources, for example, a processor, ROM, RAM, and various integrated circuits can be used. As software resources, for example, programs such as an operating system and an application can be used.

Industrial Applicability

[0053]

The present disclosure relates to a combustion device and the like.

Reference Signs List

[0054]

- 1 combustion section
- 7A automatic gate valve
- 9 fluid flow unit
- 11 furnace
- 14 fuel supply unit
- 14I fuel feed port
- 14O fuel charging port
- 81 temperature sensor
- 82 pressure sensor
- 83 flow rate sensor
- 84 incombustible-fluid supply unit
- 141 fuel storage unit
- 143 feeder
- 144 rotary valve

CLAIMS

1. A combustion device that charges a fuel into a combustion chamber to burn the fuel, the combustion device comprising:

a fuel supply unit including a fuel feed port through which the fuel is supplied and a fuel charging port through which the fuel is charged into the combustion chamber; and

an opening/closing unit that opens and closes the fuel feed port in accordance with a state quantity between the fuel feed port and the fuel charging port.

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

a state quantity acquisition unit that acquires the state quantity representing a state in the fuel supply unit between the fuel feed port and the fuel charging port.

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

a fluid flow unit that causes a fluid to flow toward the fuel charging port in the fuel supply unit,

wherein the state quantity is at least one of a pressure and a flow rate of the fluid.

4. The combustion device according to claim 3,
wherein the fluid is a gas.

5. The combustion device according to claim 1,
wherein the state quantity is a temperature in the fuel
supply unit.

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

wherein the opening/closing unit opens the fuel feed
port when the state quantity is within a predetermined
allowable range, and closes the fuel feed port when the state
quantity is outside the allowable range.

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

an incombustible-fluid supply unit that supplies an
incombustible fluid into the fuel supply unit when the state
quantity is outside a predetermined allowable range.

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

wherein the fuel is a solid fuel.

9. The combustion device according to claim 8,

wherein the solid fuel is a biomass fuel.

10. The combustion device according to claim 8,
wherein the fuel supply unit includes a solid fuel transport unit that transports the solid fuel supplied from the fuel feed port to the fuel charging port.

11. A combustion method of charging a fuel into a combustion chamber to burn the fuel, the combustion method comprising:

opening and closing a fuel feed port through which the fuel is supplied, in accordance with a state quantity between the fuel feed port and a fuel charging port through which the fuel is charged into the combustion chamber.

12. A storage medium that stores a combustion program for charging a fuel into a combustion chamber to burn the fuel and causing a computer to execute:

opening and closing a fuel feed port through which the fuel is supplied, in accordance with a state quantity between the fuel feed port and a fuel charging port through which the fuel is charged into the combustion chamber.