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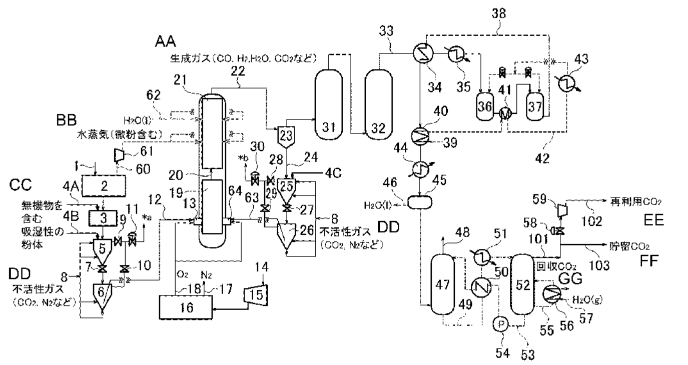
(54) **Title:** SOLID FUEL GASIFICATION SYSTEM

(54) 発明の名称： 固体燃料のガス化システム



AA Generated gas
BB Water vapour (containing fine powder)
CC Moisture-absorbing powder containing inorganic substance
DD Inert gas (such as CO_2 and N_2)
EE CO_2 for re-use
FF Stored CO_2
GG Collected CO_2

(57) **Abstract:** This gasification system comprises a drying means 2, a pulverisation means 3, air-flow conveyance means 5, 6, 12 and a gasification furnace 19. The drying means 2 dries a solid fuel 1, and the pulverisation means 3 pulverises the solid fuel 1. The air-flow conveyance means 5, 6, 12 conveys the solid fuel dried by the drying means 2 and pulverised by the pulverisation means 3 to the gasification furnace 19 by air flow. The gasification furnace 19 gasifies the solid fuel conveyed by the air-flow conveyance means 5, 6, 12 by air flow. The gasification system is provided with a powder supply system that supplies moisture-absorbing powder 4A, 4B containing an inorganic substance to at least one point from the pulverisation means 3 to the gasification furnace 19.

(57) 要約：ガス化システムは、乾燥手段２と、粉砕手段３と、気流搬送手段５，６，１２と、ガス化炉１９とを備える。乾燥手段２は、固体燃料１を乾燥し、粉砕手段３は、固体燃料１を粉砕する。気流搬送手段５，６，１２は、乾燥手段２で乾燥され、かつ粉砕手段３で粉砕された固体燃料を、ガス化炉１９に気流搬送する。ガス化炉１９は、気流搬送手段５，６，１２で気流搬送された固体燃料をガス化する。ガス化システムには、無機物を含み、かつ吸湿性を有する粉体４Ａ，４Ｂを、粉砕手段３からガス化炉１９までの少なくとも１箇所以上に供給する粉体供給系統が設けられている。

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[続葉有]

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TECHNICAL FIELD

[0001]

The present invention relates to a gasification system that gasifies solid fuel.

BACKGROUND

[0002]

Coal will continue to be one of significant energy sources in the future since there are abundant reserves thereof and it is produced all over the world. Currently, smokeless coal and bituminous coal, which are high in the amount of heat produced per unit weight, are mainly used, but it is necessary to promote the use of subbituminous coal and lignite in the future because they constitute approximately half the reserves. Subbituminous coal and lignite have a higher moisture content and produce lower heat per unit weight on a dry basis than bituminous coal or smokeless coal. Lignite in particular has a very high moisture content of approximately 30 wt% to 70 wt%, and dry lignite is likely to combust spontaneously. Due to these properties, costs for transport and storage of lignite are high, and for this reason lignite is used only around coal-producing regions.

[0003]

As one of the measures for promoting the use of lignite, there is a lignite-using gasification system. This system extracts a product gas containing CO and H_2 as main components from lignite and converts this product gas into hydrogen, methane, methanol, dimethyl ether (DME), synthetic natural gas (SNG), and so on. This system converts lignite to a transportable product gas with high added values and the product gas is used for electricity, chemical feedstocks, fuels for social infrastructure, or the like.

[0004]

In many cases, a gasifier used in this gasification system uses an entrained bed gasification method, in which the temperature of the inside of the gasifier is increased to transform coal ash into molten slag, thereby separating the coal ash from a product gas. The molten slag flows down on the surfaces of the gasifier walls made of a heat-resistant material, and consequently, the heat-resistant material of the gasifier walls may be dissolved and abraded due to, for example, erosion by the molten slag. To continue the operation of the gasifier for a long period of time, it is indispensable to continuously cause the molten slag to adhere to the surfaces of the gasifier walls, thereby forming a slag coating for reducing the dissolution and abrasion of the heat-resistant material.

[0005]

Many types of lignite have a low ash content (e.g., several percent or lower), and it is known that even lignite of the same type has varying ash melting points due to a change in the ash properties. Lignite gasification needs a gasifier operating system and a gasification system that maintain the formation of a slag coating inside the gasifier even when lignite used is of a type with a low ash content and varies in ash properties. Furthermore, the lignite gasification needs a gasifier and a gasification system that can reduce the power for drying lignite in the pretreatment.

[0006]

Patent Literature 1 describes an operation method for maintaining the formation of a slag coating inside the gasifier by adding, to lignite, an ash content adjuster (a mineral such as limestone or silica sand and a powder of an oxide of slag, heat-resistant material, cement, or the like) to adjust the ash content to 2 wt% to 19 wt% (or preferably 6 wt% to 10 wt%).

[0007]

Further, Patent Literature 2 describes a gasification system that maintains the formation of a slag coating in a gasifier by adding powdered slag collected from the gasifier to a char supply system that recirculates char produced in the gasifier to the gasifier and supplying the mixture to the gasifier.

PATENT LITERATURE

[0008]

Patent Literature 1: Japanese Patent Application Publication No. 2012-172080

[0009]

Patent Literature 2: Japanese Patent Application Publication No. 2014-136764

[0010]

One of conceivable measures for reducing the power for drying lignite is a gasification system in which lignite with a high moisture content is supplied to the gasifier. In this gasification system, the lignite with a high moisture content needs to be pulverized and transported to the gasifier.

[0011]

However, in a gasification system in which solid fuel containing high percentage of moisture (high-moisture solid fuel) is supplied to the gasifier, moisture contained in the solid fuel may evaporate and condense at low-temperature locations and the like between a drying unit and the gasifier, i.e., in a pulverizer and/or a conveyance system. When moisture condenses inside the pulverizer or the conveyance system, the solid fuel adhering to the condensed moisture causes the solid fuel to further adhere and accumulate thereto. Then, the supply amount of solid fuel may decrease, and the pulverizer or the conveyance system may be eventually clogged up.

[0012]

For example, in a pulverizer operated at a temperature (e.g., approximately 40 °C to 70 °C) higher than normal temperature, moisture condensation tends to occur near the wall surfaces and the outlet, where the temperature is lower than the operational temperature. Further, when solid fuel which is locally increased in temperature due to, for example, friction heat produced by the pulverization of the solid fuel adheres and accumulates to the inside (e.g., near the wall surfaces) of the pulverizer, the solid fuel may combust spontaneously inside the pulverizer. Further, in a hopper that stores solid fuel in the conveyance system, moisture condensation tends to occur near the wall surfaces or the solid fuel inlet or outlet when, for example, the temperature of outside air is lower than the temperature inside the hopper.

[0013]

In the operating method described in Patent Literature 1, a mineral such as limestone or silica sand or a powder of an oxide of slag, heat-resistant material, cement, or the like is added to lignite as an ash content adjuster. However, there is no mentioning of the location where the ash content adjuster is added or advantageous effects other than ash content adjustment. There is also no mentioning of preventing solid fuel from adhering and accumulating as a result of condensation of moisture evaporated from the solid fuel in a pulverizer or a conveyance system and from combusting spontaneously. For these reasons, the method of Patent Literature 1 is not assumed to be used for high-moisture solid fuel (such as lignite).

[0014]

In the operating method described in Patent Literature 2, powdered slag collected from a gasifier is added to a hopper in the char supply system that recirculates char produced in the gasifier to the gasifier. However, Patent Literature 2 is not assumed to be used for high-moisture solid fuel either.

[0015]

As thus described, the methods of Patent Literatures 1 and 2 are not assumed to be used for high-moisture solid fuel, and therefore do not consider concerns about using high-moisture solid fuel, that is, prevention of clogging up caused by adhesion and accumulation of solid fuel due to condensation of moisture evaporated from the solid fuel and spontaneous combustion of the solid fuel. Thus, high-moisture solid fuel cannot be used for the process described in Patent Literature 1 or 2.

[0016]

In at least some aspects, the present invention may provide a gasification system capable of using high-moisture solid fuel, reducing drying power, and operating stably even if the solid fuel pulverized and conveyed has a high moisture content.

[0016a]

It is desired to address or alleviate one or more disadvantages or limitations of the prior art, or to at least provide a useful alternative.

SUMMARY

[0016b]

One or more embodiments of the present invention comprise a solid fuel gasification system comprising a drying unit that dries solid fuel, a pulverizing unit that pulverizes the solid fuel, a pneumatic conveying unit that pneumatically conveys the solid fuel dried by the drying unit and then pulverized by the pulverizing unit to a gasifier, and the gasifier that gasifies the solid fuel pneumatically conveyed by the pneumatic conveying unit, wherein the solid fuel gasification system comprises a powder supply system that supplies a powder which is hygroscopic and contains inorganic matter to at least one location from the pulverizing unit to the gasifier. The solid fuel gasification system further comprises a control device that finds an amount of the powder to be supplied from the powder supply system, based on a predicted evaporation amount of moisture in a place to which the powder is to be supplied.

[0016c]

Further embodiments of the present invention comprise a solid fuel gasification system comprising a drying unit that dries solid fuel, a pulverizing unit that pulverizes the solid fuel, a pneumatic conveying unit that pneumatically conveys the solid fuel dried by the drying unit and then pulverized by the pulverizing unit to a gasifier, the gasifier that gasifies the solid fuel pneumatically conveyed by the pneumatic conveying unit, a dust removing unit that separates char from a product gas produced in the gasifier and collects the char, and a char pneumatic conveying unit that pneumatically conveys the char collected by the dust removing unit to the gasifier, wherein the solid fuel gasification system comprises a powder supply system that supplies a powder which is hygroscopic and contains inorganic matter to at least one location from the pulverizing unit to the gasifier and to at least one location from the char pneumatic conveying unit to the gasifier. The solid fuel gasification system further comprises a control device that finds an amount of the powder to be supplied from the powder supply system, based on a predicted evaporation amount of moisture in a place to which the powder is to be supplied.

[0016d]

Further embodiments of the present invention comprise a solid fuel gasification system comprising a drying unit that dries solid fuel, a pulverizing unit that pulverizes the solid fuel, a pneumatic conveying unit that pneumatically conveys the solid fuel dried by the drying unit and then pulverized by the pulverizing unit to a gasifier, the gasifier that gasifies the solid fuel pneumatically conveyed by the pneumatic conveying unit, and a dust removing unit that separates char from a product gas produced in the gasifier and collects the char, the solid fuel gasification system supplying the char collected by the dust removing unit to the pneumatic conveying unit to pneumatically convey the char to the gasifier along with the solid fuel, wherein the solid fuel gasification system comprises a powder supply system that supplies a powder which is hygroscopic and contains inorganic matter to at least one location from the pulverizing unit to the gasifier. The solid fuel gasification system further comprises a control device that finds an amount of the powder to be supplied from the powder supply system, based on a predicted evaporation amount of moisture in a place to which the powder is to be supplied.

BRIEF DESCRIPTION OF DRAWINGS

[0035]

One or more embodiments of the present invention are hereinafter described, by way of example only, with reference to the accompanying drawings in which:

[Fig. 1] Fig. 1 is a system diagram schematically showing a high-moisture coal gasification system according to a first embodiment of the present invention.

[Fig. 2] Fig. 2 is a system diagram schematically showing a high-moisture coal gasification system according to a second embodiment of the present invention.

[Fig. 3] Fig. 3 is a system diagram schematically showing a high-moisture coal gasification system according to a third embodiment of the present invention.

[Fig. 4] Fig. 4 is a system diagram schematically showing a high-moisture coal gasification system according to a fourth embodiment of the present invention.

[Fig. 5] Fig 5 is a diagram of the functional configuration of a control device provided in the high-moisture coal gasification system in Fig. 4.

DETAILED DESCRIPTION

[0017]

Gasification systems according to first to third aspects of the present invention comprise a drying unit, a pulverizing unit, a pneumatic conveying unit, and a gasifier. The drying unit dries solid fuel, and the pulverizing unit pulverizes the solid fuel. The pneumatic conveying unit pneumatically conveys the solid fuel dried by the drying unit and then pulverized by the pulverizing unit to the gasifier. The gasifier gasifies the solid fuel pneumatically conveyed by the pneumatic conveying unit.

[0018]

The gasification system according to the first aspect of the present invention is provided with a powder supply system that supplies a powder which is hygroscopic and contains inorganic matter to at least one location from the pulverizing unit to the gasifier.

[0019]

The gasification system according to the second aspect of the present invention comprises a dust removing unit that separates char from a product gas produced in the gasifier and collects the char, and a char pneumatic conveying unit that pneumatically conveys the char collected by the dust removing unit to the gasifier. The gasification system according to the second aspect is provided with a powder supply system that supplies a powder which is hygroscopic and contains inorganic matter to at least one location from the pulverizing unit to the gasifier and to at least one location from the char pneumatic conveying unit to the gasifier.

[0020]

The gasification system according to the third aspect of the present invention comprises a dust removing unit that separates char from a product gas produced in the gasifier and collects the char, and the gasification system supplies the char collected by the dust removing unit to the pneumatic conveying unit to pneumatically convey the char to the gasifier along with the solid fuel. The gasification system according to the third aspect is provided with a powder supply system that supplies a powder which is hygroscopic and contains inorganic matter to at least one location from the pulverizing unit to the gasifier.

[0021]

When solid fuel that contains high percentage of moisture (e.g., 25 wt% or higher) is pulverized by a pulverizing unit and pneumatically conveyed to a gasifier by a pneumatic conveying unit, the solid fuel may adhere and accumulate in the pulverizing unit or the pneumatic conveying unit due to condensation of moisture evaporated from the solid fuel.

[0022]

To reduce such adhesion and accumulation of the solid fuel, the gasification systems of the first to third aspects are provided with a powder supply system that supplies a powder which is hygroscopic and contains inorganic matter to a location from the pulverizing unit to the gasifier. The supply of the powder can dehumidify the moisture evaporated from the solid fuel and reduce adhesion and accumulation of the solid fuel due to condensation of the moisture.

[0023]

The pulverizing unit in particular is operated at a temperature (e.g., approximately 40 °C to 70 °C) higher than normal temperature, and may even locally reach a temperature higher than the operational temperature of the pulverizing unit due to such factors as friction heat generated by pulverization. Then, the adhering and accumulating solid fuel is at risk of spontaneous combustion. By configuring the powder supply system such that the powder is supplied to the pulverizing unit, adhesion and accumulation of the solid fuel inside the pulverizing unit are reduced to prevent the solid fuel from combusting spontaneously in the pulverizing unit.

[0024]

Thus, a gasification system can be constructed which is capable of using high-moisture solid fuel, reducing power for drying the solid fuel in the drying unit, and operating stably even if the solid fuel pulverized and conveyed has a high moisture content.

[0025]

Further, in the second aspect, the powder is supplied to a location from the char pneumatic conveying unit to the gasifier, and thereby moisture evaporated from the char is dehumidified, which can reduce adhesion and accumulation of the char due to condensation of the moisture.

[0026]

A fourth aspect of the present invention is the gasification system of any one of the first to third aspects, in which the pneumatic conveying unit has a fuel hopper. The powder supply system supplies the powder to each of the pulverizing unit and the fuel hopper individually.

[0027]

A fifth aspect of the present invention is the gasification system of the second aspect, in which the pneumatic conveying unit has a fuel hopper, and the char pneumatic conveying unit has a char hopper. The powder supply system supplies the powder to each of the pulverizing unit, the fuel hopper, and the char hopper individually.

[0028]

A sixth aspect of the present invention is the gasification system according to the fourth or fifth aspect, in which the drying unit has a first drying unit and a second drying unit. The pulverizing unit pulverizes the solid fuel dried by the first drying unit. The second drying unit dries the solid fuel pulverized by the pulverizing unit. The pneumatic conveying unit is provided with an upper burner pneumatic conveyance system that supplies the solid fuel pulverized by the pulverizing unit to an upper burner of the gasifier and a lower burner pneumatic conveyance system that supplies the solid fuel pulverized by the pulverizing unit to a lower burner of the gasifier. The fuel hopper includes an upper burner hopper provided to the upper burner pneumatic conveyance system and a lower burner hopper provided to the lower burner pneumatic conveyance system. The powder supply system supplies the powder to each of the upper burner hopper and the lower burner hopper individually.

[0029]

In a case where the fuel hopper is provided to the pneumatic conveying unit, if, for example, the temperature of outside air is lower than the internal temperature of the hopper, moisture evaporated from the solid fuel may condense near the wall surfaces or the solid fuel inlet or outlet.

[0030]

To reduce adhesion and accumulation of the solid fuel in the fuel hopper, the gasification systems of the fourth to sixth aspects supply the powder to the fuel hopper. The supply of the powder can reduce the development of condensed water in the hopper and prevent a decrease in the supply amount of solid fuel and clogging up of the solid fuel conveyance system.

[0031]

Further, in the fifth aspect, the powder is supplied to the char hopper, and thereby clogging up of the char conveyance system can be prevented.

[0032]

A seventh aspect of the present invention is the gasification system of any one of the first to sixth aspects, in which the solid fuel gasification system is provided with a control device that finds an amount of the powder to be supplied from the powder supply system, based on a predicted evaporation amount of moisture in a place to which the powder is to be supplied.

[0033]

Since the gasification system of the seventh aspect is provided with a control device that finds an amount of the powder to be supplied from the powder supply system based on a predicted evaporation amount of moisture in a place to which the powder is to be supplied, the amount of the supplied powder can be minimized.

[0034]

The gasification system of at least some aspects of the present invention is capable of using high-moisture solid fuel, reducing drying power, and operating stably even if the solid fuel pulverized and conveyed has a high moisture content.

[0036]

With reference to the drawings, high-moisture coal gasification systems according to embodiments of the present invention will be described below.

[0037]

(First Embodiment)

Fig. 1 shows a system diagram of a high-moisture coal gasification system provided with a system (a powder supply system) that supplies a powder which is hygroscopic and contains inorganic matter (hereinafter referred to as a hygroscopic powder containing inorganic matter) to a location from a pulverizing unit for solid fuel 1 to a gasifier.

[0038]

As shown in Fig. 1, the solid fuel 1 is dried by a drying device (drying unit) 2 and pulverized by a pulverizing device (pulverizing unit) 3, and is then increased in pressure to a predetermined pressure and stored in a lock hopper 5 and transported to a feed hopper 6. Accompanied by an inert gas 8, the solid fuel 1 is supplied from the feed hopper 6 to a gasifier 19 via a solid fuel conveyance pipe 12 and a solid fuel burner 13. The conveyance path of the solid fuel 1 from the lock hopper 5 to the gasifier 19 via the feed hopper 6 constitutes a pneumatic conveying unit that pneumatically conveys the solid fuel 1 dried by the drying device 2 and then pulverized by the pulverizing device 3 to the gasifier 19.

[0039]

N_2, CO_2, or the like is preferable as the inert gas 8 used in the transport and conveyance of the solid fuel 1. In a case of using N_2 as the inert gas 8, nitrogen 17 manufactured from air 14 supplied to an air separator 16 can be used. In a case of using CO_2 as the inert gas 8, CO_2 collected in the gasification system (hereinafter referred to as collected CO_2 (101)) can be used. For example, part of the collected CO_2 (101) is taken, is increased in pressure to a predetermined pressure by a reuse CO_2 compressor 59, and is used as reuse CO_2 (102). The flow rate of this reuse CO_2 (102) is controlled by a reuse CO_2 flow rate regulating valve 58. In the gasification system described in the present embodiment, CO_2 is used as the inert gas 8.

[0040]

Before a transport valve 7 is opened to transport the solid fuel 1 from the lock hopper 5 to the feed hopper 6, the lock hopper 5 and the feed hopper 6 are equalized in pressure by opening a lock hopper pressure equalizing valve 9 and a feed hopper pressure equalizing valve 10. Further, the inert gas 8 for transport (CO_2 in the present embodiment) is charged into the lock hopper 5 to prevent the solid fuel 1 from stagnating at the outlet of the lock hopper 5 or at the transport valve 7. A pressure regulating valve 11 is used to control the pressures of the hoppers at the time of transport.

[0041]

CO_2 which contains particulate solid fuel 1 (in the form of powdery dust) is exhausted from the pressure regulating valve 11. This exhausted CO_2 may be reused as the inert gas 8 or mixed in the system for stored CO_2 (103). To mix the exhausted CO_2

in the system for stored CO_2 (103), the powdery dust in the exhausted CO_2 needs to be removed by a dust removal process.

[0042]

Accompanied by the inert gas 8 (CO_2 in the present embodiment), the solid fuel 1 transported to the feed hopper 6 is supplied to the gasifier 19 via the solid fuel conveyance pipe 12 and the solid fuel burner 13. The solid fuel 1 charged into the gasifier 19 is mixed with oxygen 18 which is also charged into the gasifier 19 via the solid fuel burner 13, and is gasified, producing a high-temperature product gas 20. The product gas 20 consists mainly of CO and H_2.

[0043]

The oxygen 18 charged into the gasifier 19 is manufactured by the air separator 16. The air 14 is increased in pressure by a compressor 15 and supplied to the air separator 16, which then separates the air 14 into the nitrogen 17 and the oxygen 18. To reduce the power for the air separator 16, a more energy efficient system may be employed which, for example, manufactures at least part of the oxygen 18 by electrolyzing water using power generated by natural energy such as sunlight or wind.

[0044]

The high-temperature product gas 20 is supplied to a product gas cooler 21. A mist of water 62 increased in pressure to a predetermined pressure is charged into the product gas cooler 21 to cool the product gas 20 down. To atomize the mist of water 62, an atomizing nozzle is placed at a port on the product gas cooler 21 through which the mist of water 62 is charged.

[0045]

Water 46 collected from a product gas after shift reaction to be described later, a coolant for molten slag produced in the gasifier 19, or the like may be used as the mist of water 62 to achieve a system that uses less industrial water.

[0046]

The product gas cooler 21 is also supplied with steam 60 which is produced in the drying device 2 for the solid fuel 1 and which contains dispersed fuel, to make effective use of excess water contained in the solid fuel 1. In most cases, the drying device 2 is operated under a pressure close to normal pressure, while the product gas cooler 21 is operated under an increased pressure. For this reason, the steam 60 containing dispersed fuel is increased in pressure by a compressor 61 and then supplied to the product gas cooler 21.

[0047]

In the system shown in the present embodiment, the steam 60 containing dispersed fuel is supplied upstream of the mist of water 62 and mixed with the high-temperature product gas 20. If the temperature of the product gas 20 after being mixed with the steam 60 containing dispersed fuel can be maintained at approximately 1000 °C or higher, a water-gas shift reaction ($CO + H_2O \rightarrow CO_2 + H_2$) proceeds by the charged steam and CO in the product gas. If the shift reaction can proceed in the product gas cooler 21, this leads to reductions in the amount of a shift reaction catalyst and the amount of water 39 for shift reaction which are used in a downstream shift reactor.

[0048]

In order to cool the high-temperature product gas 20 in a short period of time and to reduce the size of the product gas cooler 21 to cut costs for constructing the gasification system, the mist of water 62 may be supplied upstream of the steam 60 containing dispersed fuel (such a system is not shown in the drawings).

[0049]

Char 24 accompanying a cooled-down product gas 22 is removed in a dust removing device (dust removing unit) 23. Then, a halogen-based substance such as chlorine and minute particles failed to be removed by the dust removing device 23 are removed in a water washing column 31, and sulfur is removed in a desulfurizing device 32.

[0050]

The char 24 separated from the cooled-down product gas 22 is stored in a char lock hopper 25 and transported to a char feed hopper 26 as needed. Then, the char 24 is charged into the gasifier 19 via a char conveyance pipe 63 and a char burner 64. The conveyance path of the char 24 from the char lock hopper 25 to the gasifier 19 via the char feed hopper 26 constitutes a char pneumatic conveying unit that pneumatically conveys the char 24 collected by the dust removing device 23 to the gasifier 19. The inert gas 8 is used as conveyance gas for the char 24. The system described in the present embodiment uses reuse CO_2 (102) as the conveyance gas, like the solid fuel 1.

[0051]

The char 24 is transported and conveyed in the same manner as the solid fuel 1 described above. To transport the char 24, a char lock hopper pressure equalizing valve 28 and a char feed hopper pressure equalizing valve 29 are opened to equalize the pressures in the char lock hopper 25 and the char feed hopper 26, and then, a char transport valve 27 is opened to transport the char 24. The inert gas 8 (CO_2 in the present embodiment) is charged for promotion of the transport of the char 24 and for control of the pressures of the hoppers, and the pressures of the hoppers are controlled by controlling the extent to which a char system pressure regulating valve 30 is opened.

[0052]

Meanwhile, a desulfurized product gas 33 consisting mainly of CO, H_2, CO_2, and H_2O (steam) is heated to approximately 200 °C to 300 °C by a product gas heat exchanger 34 and a product gas heater 35, and is then supplied to a first shift reactor 36. The temperature to which the desulfurized product gas 33 is heated is set according to the characteristics of a shift reaction catalyst loaded to the first shift reactor 36.

[0053]

In the first shift reactor 36, the desulfurized product gas 33 is mixed with steam 42 for shift reaction, and thereby the shift reaction proceeds. When the shift reaction, which is an exothermic reaction, proceeds excessively, a reaction container or the shift reaction catalyst may be at risk of being damaged by the high-temperature product gas. Thus, a plurality of shift reactors may be placed so that the shift reaction may proceed in stages as the product gas is cooled down. The present embodiment describes a case where two shift reactors are placed.

[0054]

Further, it is necessary to adjust the shift reaction rate according to the purpose of the product gas (H_2, methane, methanol, dimethyl ether (DME), synthetic natural gas (SNG)), and to adjust the ratio of CO and H_2 contained in a product gas 38 after shift reaction to a predetermined ratio. This adjustment of the shift reaction rate may be done by changing the operational conditions such as the temperature of the shift reactor and the amount of steam added and/or by increasing or decreasing the amount of catalyst loaded. In some cases, a system that bypasses a second shift reactor 37 may be provided.

[0055]

The desulfurized product gas 33 is supplied to the second shift reactor 37 after being cooled down to a predetermined temperature downstream of the first shift reactor 36. For the cooling down, a heat exchanger 41 of product gas after first shift reaction and water for shift reaction can be used, and the shift reaction heat can be used to preheat the steam 42 for shift reaction.

[0056]

The product gas 38 after shift reaction is cooled down to approximately 40 °C by the product gas heat exchanger 34, a heat exchanger 40 of product gas after shift reaction and water for shift reaction, and a cooler 44 for product gas after shift reaction.

[0057]

Condensed water produced by this cooling process is separated by a knockout drum 45, and is collected as water 46 collected from the product gas 38 after shift reaction. The water 46 collected from the product gas 38 after shift reaction is preferably reused in the gasification system as the mist of water 62 or the like, although not shown in Fig. 1. The water 46 collected from the product gas 38 after shift reaction may be contaminated by by-products such as methanol generated by CO and H_2O (steam) remaining in the product gas 38 after shift reaction. The water 46 collected from the product gas 38 after shift reaction is sprayed into the product gas cooler 21 and is vaporized to decompose into by-products such as methanol. This way, there is no need for a device for processing the by-products contained in the water 46 collected from the product gas 38 after shift reaction.

[0058]

The product gas 38 after shift reaction thus cooled down to approximately 40 °C is removed of CO_2 in a CO_2 absorbing column 47 and becomes a product gas 48 after CO_2 absorption. This product gas 48 after CO_2 absorption is used for purposes such as power generation, fuel for social infrastructure, or chemical feedstocks.

[0059]

In the CO_2 absorbing column 47, a CO_2 absorption solution 53 consisting mainly of methyldiethanolamine comes into contact with the product gas 38 after shift reaction, thereby separating and removing CO_2. A CO_2 absorption solution 49 which has absorbed CO_2 is heated up to 100 °C or higher by a CO_2 absorption solution heat exchanger 50 and a CO_2 absorption solution heater 51, and is supplied to a CO_2 regenerating column 52. In the CO_2 regenerating column 52, CO_2 contained in the CO_2 absorption solution 49 which has absorbed CO_2 is released.

[0060]

Thereby, the CO_2 absorption solution 49 which has absorbed CO_2 can be reused as the CO_2 absorption solution 53. The CO_2 absorption solution 53 is increased in pressure by a pressure boost pump 54 for CO_2 absorption solution, is cooled down to approximately 40 °C by the CO_2 absorption solution heat exchanger 50, and is supplied to the CO_2 absorbing column 47.

[0061]

Although the present embodiment shows a gasification system employing a CO_2 collection method using chemical absorption with methyldiethanolamine, a different CO_2 collection method may be used alternatively.

[0062]

In gasification of the solid fuel 1 having a high moisture content (e.g., 25 wt% or higher) in the above-described gasification system, moisture in the solid fuel 1 at the outlet of the drying device 2 is set to be higher than that in a conventional typical system (approximately 15 wt% or lower). For this reason, according to the high-moisture coal gasification system of the present embodiment, a high-moisture coal gasification system with high energy efficiency can be constructed, in which power for drying the solid fuel 1 in the drying device 2 is reduced compared to that in a conventional typical system.

[0063]

In this system, the high-moisture solid fuel 1 is supplied to the pulverizing device 3, where the solid fuel 1 is at risk of adhering to the inner walls and/or the like of the pulverizing device 3. The pulverizing device 3 is operated at a temperature (e.g., approximately 40 °C to 70 °C) higher than normal temperature, and may locally reach an even higher temperature due to such factors as friction heat generated by pulverization. For this reason, moisture remaining in the solid fuel 1 may evaporate in the pulverizing device 3. The evaporated moisture may condense when cooled by outside air near the inner walls of the pulverizing device 3, and adhere and accumulate to the inner walls along with the solid fuel 1. When adhering and accumulating to the inside of the pulverizing device 3, the solid fuel 1 is at risk of hindering the operation of the pulverizing device 3 or combusting spontaneously.

[0064]

For these reasons, a system for supplying a hygroscopic powder 4A containing inorganic matter is placed for the pulverizing device 3. The powder 4A supplied into the pulverizing device 3 absorbs moisture evaporated in the pulverizing device 3, and is discharged and stored in the lock hopper 5 along with the solid fuel 1.

[0065]

The lock hopper 5 is supplied with the inert gas 8, is increased in pressure to a predetermined pressure, and stores the solid fuel 1 for up to several tens of minutes or so (the storage time varies depending on the capacity of the hopper and the amount of solid fuel 1 supplied). The inside temperature of the lock hopper 5 exceeds that of outside air if, for example, the solid fuel 1 stored therein has a higher temperature than outside air, the inert gas 8 supplied thereto for pressure boosting, transport, or the like has a higher temperature than outside air, or the temperature of the outside air decreases during storage.

[0066]

In such a case, moisture evaporated from the solid fuel 1 may condense at such locations as near the wall surfaces, the inlet, and the outlet of the lock hopper 5, where the atmosphere temperature is decreased by heat radiation to the outside air. In a system that pneumatically conveys the solid fuel 1 to the gasifier 19, adhesion and accumulation of the solid fuel 1 along with the condensed moisture may eventually clog up such locations as the inlet and outlet of the hopper.

[0067]

Thus, a system for supplying a hygroscopic powder 4B containing inorganic matter is placed for the lock hopper 5. The powder 4B supplied into the lock hopper 5 absorbs moisture evaporated from the solid fuel 1 stored in the lock hopper 5, and is transported along with the solid fuel 1 to the feed hopper 6 via the solid fuel transport valve 7.

[0068]

The solid fuel 1 thus transported to the feed hopper 6 is stored in the feed hopper 6 in a similar manner to the lock hopper 5 described above, and therefore moisture evaporated from the solid fuel 1 may condense. If the solid fuel 1 adheres and accumulates, along with the condensed moisture, to such locations as the inlet and the inner walls of the hopper, near the inlet of the conveyance pipe 12, and the inside of the conveyance pipe 12, the flow rate of the solid fuel 1 supplied to the gasifier 19 may drastically decrease.

[0069]

The powder 4B supplied to the lock hopper 5 and transported from the lock hopper 5 along with the solid fuel 1 may not be enough to absorb moisture produced inside the feed hopper 6. In such a case, although not shown, an additional system for supplying a hygroscopic powder containing inorganic matter may be placed between the feed hopper 6 and the gasifier 19, or at, for example, the feed hopper 6, the solid fuel conveyance pipe 12, or the like.

[0070]

Further, in this system, the char 24 collected, stored in the char lock hopper 25, transported to the char feed hopper 26, and then charged into the gasifier 19 via the char conveyance pipe 63 and the char burner 64 has a higher moisture content than a case where the solid fuel used has a low moisture content. The inside temperature of the char lock hopper 25 exceeds that of outside air if, for example, the char 24 stored therein has a higher temperature than outside air, the inert gas 8 supplied thereto for pressure boosting, transport, or the like has a higher temperature than outside air, or the temperature of the outside air decreases during storage.

[0071]

In such a case, moisture evaporated from the char 24 may condense at such locations as near the wall surfaces, the inlet, and the outlet of the char lock hopper 25, where the atmosphere temperature is decreased by heat radiation to the outside air. Adhesion and accumulation of the char 24 along with the condensed moisture may eventually clog up such locations as the inlet and outlet of the char lock hopper 25.

[0072]

To address this, a system for supplying a hygroscopic powder 4C containing inorganic matter is placed for the char lock hopper 25. The powder 4C supplied into the char lock hopper 25 absorbs moisture evaporated from the char 24 stored in the char lock hopper 25, and is transported along with the char 24 to the char feed hopper 26 via the char transport valve 27.

[0073]

Lastly, a description is given of the hygroscopic powder containing inorganic matter. Examples of the hygroscopic powder containing inorganic matter include coal ash, ash from waste incineration, zeolite (including artificial zeolite made from coal ash or the like), silica gel, and calcium carbonate.

[0074]

For example, if the high-moisture coal gasification system of the present embodiment is installed near a pulverized coal boiler or near a lignite boiler operated close to a lignite mine, coal ash produced by these boilers can be effectively used as the hygroscopic powder containing inorganic matter. Further, if the high-moisture coal gasification system of the present embodiment is installed next to a waste incinerator, waste incineration ash produced in this waste incinerator may be used.

[0075]

Organic matter (unburnt combustible content) in coal ash, waste incineration ash, or the like is gasified in the gasifier 19, and inorganic matter therein is eventually formed into molten slag in the gasifier 19. Molten slag can help prevent heavy metal or the like from leaching into intruding water, which is a concern about coal ash and waste incineration ash, and also, can be effectively used as a pavement material, aggregate, or the like. Thereby, detoxification of ash produced in a boiler or a waste incinerator and a positive contribution to enhanced recycling can be achieved.

[0076]

According to the above system that gasifies the high-moisture solid fuel 1, a gasification system with high energy efficiency can be constructed by the reduction in the power for drying the solid fuel 1.

[0077]

In the present embodiment, a powder supply system is provided to supply the hygroscopic powders 4A, 4B, 4C containing inorganic matter to the pulverizing device 3, the lock hopper 5, and the char lock hopper 25, respectively. Alternatively, the powder supply system may supply the power to one or two of the pulverizing device 3, the lock hopper 5, and the char lock hopper 25, or the powder supply system may supply a hygroscopic powder containing inorganic matter to a location other than the above.

[0078]

(Second Embodiment)

Fig. 2 shows a system diagram of a high-moisture coal gasification system provided with a system for supplying the char 24 collected by the dust removing unit to the solid fuel pneumatic conveying unit. In the present embodiment, points different from Fig. 1 showing the first embodiment are mainly described. Note that in the present embodiment, a plurality of solid fuel burners 13 and 13A are provided, and the char burner 64 is not provided.

[0079]

As shown in Fig. 2, the char 24 collected by the dust removing device 23 is supplied to the lock hopper 5 and is transported to the feed hopper 6 along with the solid fuel 1. The following describes an operation procedure of how the solid fuel 1, which is supplied from the pulverizing device 3 at normal pressure, and the char 24, which is supplied at increased pressure almost equivalent to the operational pressure of the gasifier 19, are supplied to the same lock hopper 5 and transported to the feed hopper 6.

[0080]

First, the solid fuel 1 pulverized by the pulverizing device 3 is supplied to the lock hopper 5 at almost normal temperature and pressure. The hygroscopic powder 4B containing inorganic matter is supplied to the lock hopper 5 along with the solid fuel 1 in this period in which the lock hopper 5 is operated at normal pressure. Once a predetermined amount of solid fuel 1 accumulates in the lock hopper 5, a solid fuel supply valve 65 is closed, the inert gas 8 is charged, and the lock hopper 5 is increased in pressure to the same pressure as the dust removing device 23.

[0081]

Next, a char supply valve 66 is opened to supply the char 24 accumulated in the dust removing device 23 to the lock hopper 5. In order to supply the char 24 smoothly here, measures may be taken, such as charging the inert gas 8 into the piping connecting the dust removing device 23 and the lock hopper 5 together, or placing a pressure equalizing pipe.

[0082]

The dust removing device 23 is operated at a temperature (e.g., 230 °C or higher if the pressure is 2.5 MPa) higher than the dew point of the cooled-down product gas 22. Thus, the char 24 flows into the lock hopper 5 at a temperature close to the operational temperature of the dust removing device 23, i.e., at a temperature much higher than normal temperature. Consequently, when the high-temperature char 24 and the high-moisture solid fuel 1 come into direct contact with each other in the lock hopper 5, and moisture contained in the solid fuel 1 is evaporated by the sensible heat of the char 24. To prevent this moisture from condensing, the hygroscopic powder 4B containing inorganic matter is supplied to the lock hopper 5 for dehumidification. In addition, although not shown, a system may be employed in which the reuse CO_2 (102) heated to a temperature higher than normal temperature by adiabatic compression by the reuse CO_2 compressor 59 is used as the inert gas 8 to retain the heat of places from the lock hopper 5 to the solid fuel burners 13 and 13A so that evaporation of moisture contained in the solid fuel 1 may be promoted. This system needs measures for the heat retention (e.g., installing steam piping or a heater for heat retention, a heat retention material, or the like), but reduces the risk of condensation of evaporated moisture due to a drop in temperature, and consequently can reduce the amount of the supplied hygroscopic powder 4B containing inorganic matter. Moreover, the solid fuel 1 and the inert gas 8 can be preheated before being charged into the gasifier 19, preventing a drop in temperature in the gasifier 19.

[0083]

Further, the char supply valve 66 is closed, the inert gas 8 is charged, and the lock hopper 5 is increased in pressure to the same pressure as the feed hopper 6.

[0084]

Lastly, the lock hopper pressure equalizing valve 9 and the feed hopper pressure equalizing valve 10 are opened to equalize the pressures of the lock hopper 5 and the feed hopper 6 which is continuously supplying the solid fuel 1 to the gasifier 19 at a constant pressure with the pressure regulating valve 11. Then, the solid fuel transport valve 7 is opened to transport the solid fuel 1 and the char 24 from the lock hopper 5 to the feed hopper 6. To prevent powder from stagnating at the bottom of the lock hopper 5, the lock hopper 5 may be shaken by a blow or the like, or the inert gas 8 may be charged.

[0085]

The solid fuel 1 and the char 24 transported to the feed hopper 6 are pneumatically conveyed by the inert gas 8, and is supplied to the gasifier 19 via the solid fuel conveyance pipe 12 and the solid fuel burners 13 and 13A.

[0086]

A method for conveying the solid fuel 1 and the char 24 from the single feed hopper 6 to the plurality of solid fuel burners 13 and 13A includes one in which a distributor 67 is placed between the feed hopper 6 and the gasifier 19 to cause the solid fuel conveyance pipe 12 to fork, and one in which a plurality of solid fuel conveyance pipes 12 are placed, extending from the feed hopper 6. The former example is employed and described in the present embodiment, but any one of them may be used, or both of them may be used in combination.

[0087]

Further, in the system described in the present embodiment, the hygroscopic powders 4A and 4B containing inorganic matter are supplied to the pulverizing device 3 and the lock hopper 5. However, the hygroscopic powder containing inorganic matter may be supplied to other locations from the pulverizing unit to the gasifier, such as the feed hopper 6, the solid fuel conveyance pipe 12, and/or the distributor 67.

[0088]

As described above, the char 24 which has been collected by the dust removing device 23 and has a higher temperature than normal temperature is supplied to the system for conveying the solid fuel 1 which is supplied having a high moisture content, is brought into direct contact with the solid fuel 1 having almost normal temperature, and is conveyed to the gasifier 19 along with the solid fuel 1. Even if moisture contained in the solid fuel 1 evaporates due to the sensible heat of the char 24 during the transport and conveyance of the solid fuel 1, condensation of the moisture is prevented by dehumidification of the present embodiment achieved by the hygroscopic powders 4A and 4B containing inorganic matter charged into locations from the pulverizing device 3 to the gasifier 19. What can be constructed thereby is a high-moisture solid fuel gasification system which has high energy efficiency due to reduction in the power for drying the solid fuel 1 and which has a simple system due to the absence of need for a system for conveying the char 24.

[0089]

(Third Embodiment)

Fig. 3 shows a system diagram of a high-moisture coal gasification system which pneumatically conveys solid fuel and char to a gasifier using a plurality of systems and is provided with a system (a powder supply system) that supplies a powder which is hygroscopic and contains inorganic matter to each of a pulverizing device and hoppers in the respective systems individually. In the present embodiment, points different from Fig. 1 showing the first embodiment are mainly described.

[0090]

The solid fuel 1 is dried in a drying device (first drying unit) 2A, pulverized by the pulverizing device 3, and then supplied to the lock hopper 5 for supplying the solid fuel 1 to an upper burner 68 and to a drying device (second drying unit) 2B for drying the solid fuel 1 further. Moisture in the solid fuel 1 after being dried by the drying device 2A is selected to a value that achieves all of the following: pneumatic conveyance to the pulverizing device 3, pneumatic conveyance to the gasifier 19, and retention of the temperature inside the gasifier 19. The pulverizing device 3 is supplied with the hygroscopic powder 4A containing inorganic matter to dehumidify moisture evaporated inside, thereby preventing condensation of the moisture inside.

[0091]

The solid fuel 1 stored in the lock hopper 5 is transported to the feed hopper 6, and is, accompanied by the inert gas 8, charged into the gasifier 19 via a solid fuel conveyance pipe 69 leading to the upper burner and then the upper burner 68. The lock hopper 5 and the feed hopper 6 are supplied with the hygroscopic powders 4B and 4F containing inorganic matter, respectively, to dehumidify the moisture evaporated in the hoppers, thereby preventing condensation of the moisture inside.

[0092]

The gasifier 19 here employs a method in which a plurality of burners are placed at different heights to make a lower part of the gasifier 19 high in temperature so that the inorganic matter in the solid fuel 1 may be formed into molten slag, while an upper part of the gasifier 19 is set to a lower temperature than the lower part of the gasifier 19 so that a combustible content (such as carbon and hydrogen) in the solid fuel 1 may be gasified. It is expected that using CO_2 for the inert gas 8 promotes CO_2 gasification reaction ($C + CO_2 \rightarrow 2CO$), and that increasing the moisture contained in the solid fuel 1 promotes steam gasification reaction ($C + H_2O \rightarrow CO + H_2$). For this reason, the moisture in the solid fuel 1 charged from the upper burner 68 is set to be higher than that in the solid fuel 1 charged from a lower burner 70. Since the system for conveying the solid fuel 1 to the upper burner 68 handles the solid fuel 1 with a higher moisture content, it is essential for this system to be operated to prevent moisture condensation.

[0093]

Moisture contained in the solid fuel 1 is known to be roughly classified into two types: adherent water adhering to the surfaces of particles and bonded water chemically bonded with a solid content by hydrogen bonding, ionic reaction, and the like. To dry the former type, adherent water, sensible heat up to a boiling point (100 °C under normal pressure) and latent heat of vaporization are necessary. By contrast, the latter type, bonded water, needs additional heat energy for extracting H_2O by breaking the chemical bond, in addition to the sensible heat and the latent heat above. From a perspective of improving the energy efficiency of the gasification system, moisture in the solid fuel 1 dried by the drying device 2A is preferably set to a value that dries at least part of the former type, adherent water.

[0094]

Next, the solid fuel 1 to be charged from the lower burner 70 is supplied to the drying device 2B and is dried further. Thereafter, the solid fuel 1 is stored in a lock hopper 72 of the lower burner system, is transported to a feed hopper 73 of the lower burner system, and is, accompanied by the inert gas 8, charged into the gasifier 19 via a solid fuel conveyance pipe 71 of the lower burner system and the lower burner 70. The lock hopper 72 of the lower burner system and the feed hopper 73 of the lower burner system are supplied with hygroscopic powders 4D and 4G containing inorganic matter, respectively, to dehumidify moisture evaporated inside the hoppers, thereby preventing condensation of the moisture inside. In addition, the char feed hopper 26 is also supplied with a hygroscopic powder 4H containing inorganic matter to dehumidify moisture evaporated in the hopper, thereby preventing condensation of the moisture inside.

[0095]

In the above-described gasification system having a system for pneumatically conveying the solid fuel 1 and the char 24 to the gasifier 19 through a plurality of systems, moisture condensation is prevented by dehumidification achieved by providing each of the pulverizing device 3, the hopper 5 of solid fuel 1, and the hopper 72 of the conveying unit of solid fuel 1 with a system for supplying a powder which is hygroscopic and contains inorganic matter, individually. Further, adjustment of moisture in the solid fuel 1 to a value suitable for gasification allows reduction in the power for drying the solid fuel in the pretreatment to make it possible to construct a high-moisture solid fuel gasification system with high energy efficiency.

[0096]

(Fourth Embodiment)

Fig. 4 shows a high-moisture coal gasification system provided with a control device for adjusting the percentage of moisture contained in dried solid fuel and the supply amounts of hygroscopic powders containing inorganic matter to be charged into a pulverizing unit, a solid fuel pneumatic conveying unit, a char pneumatic conveying unit, and a gasifier. In the present embodiment, differences from Fig. 3 showing the third embodiment are mainly described.

[0097]

As shown in Fig. 4, in the present embodiment, an additional system is provided to supply a hygroscopic powder 4E containing inorganic matter to the gasifier 19 as well. This system is additionally provided to add a function to maintain a slag coating formed on a lower part inside the gasifier 19 by adding inorganic matter contained in the hygroscopic powder 4E containing inorganic matter to the inorganic matter (ash) contained in the solid fuel 1 to adjust the flow rate of inorganic matter to be formed into molten slag in the gasifier 19 and the viscosity of the molten slag.

[0098]

Further, the gasification system of the present embodiment is provided with a control device 78 having a function to regulate the flow rate for each of the pulverizing device 3, the lock hopper 5, the char lock hopper 25, the lock hopper 72 of the lower burner system, and the gasifier 19, which are supplied with the hygroscopic powders 4A, 4B, 4C, 4D, 4E containing inorganic matter. The outline of the flow rate regulation logic of the control device 78 is described.

[0099]

As shown in Fig. 5, first, based on analysis values of the solid fuel 1, total moisture (the amount of moisture contained in the solid fuel before being dried), an adherent water content (a bonded water content is calculated based on bonded water content = total moisture – adherent water content), an ash content (i.e., inorganic matter), an ash melting point, ash composition, and industrial analysis (composition of organic matter such as C, H, and O) are acquired. Based on these, the temperature inside the gasifier for forming ash into molten slag at the lower part of the gasifier 19, the flow rate of the solid fuel 1 charged into the gasifier 19, the flow rate of ash (inorganic matter) to be formed into molten slag inside the gasifier 19 are set in the control device 78.

[0100]

Next, the amount of moisture in the solid fuel 1 to be charged into the gasifier 19 and the amount of oxygen for gasification of the solid fuel 1 are set. Based on these, the following values are set: a target moisture content (a target moisture content percentage) in the solid fuel after being dried by the drying device 2A and a target moisture content in the solid fuel after being dried by the drying device 2B, a predicted evaporation amount of moisture in the pulverizing device 3 based on the operational temperature of the pulverizing device 3, the temperature of the cooled-down product gas 22, and the percentage of steam contained in the cooled-down product gas 22. In the present embodiment, the predicted evaporation amount of moisture in the pulverizing device 3, the temperature of the cooled-down product gas 22, and the percentage of steam contained in the cooled-down product gas 22 are set in the control device 78.

[0101]

Further, the supply temperature of the inert gas 8 and the target temperature of the inner walls of the char lock hopper 25 are determined, and based on these and the analysis values of the solid fuel 1 above, predicted amounts of moisture that evaporates in the lock hopper 5 that supplies the solid fuel 1 to the upper burner 68, in the lock hopper 72 of the lower burner system, and in the char lock hopper 25 are predicted, and these predicted values are set in the control device 78.

[0102]

Based on these predicted values and the operational temperatures of the respective devices, the control device 78 calculates the flow rate of each of the hygroscopic powders 4A, 4B, 4C, 4D containing inorganic matter needed to prevent evaporated moisture from condensing inside the pulverizing device 3, the lock hopper 5, the lock hopper 72 of the lower burner system, and the char lock hopper 25.

[0103]

Lastly, the flow rate of the inorganic matter to be formed into molten slag in the gasifier 19 and the viscosity of the molten slag are adjusted, and if the total flow rate of the hygroscopic powders 4A to 4D containing inorganic matter charged into the gasifier 19 is insufficient from a perspective of maintaining a slag coating formed in a lower part inside the gasifier 19, the flow rate of the hygroscopic powder 4E containing inorganic matter to be charged into the gasifier 19 is found to charge the powder 4E into the gasifier 19 to compensate for the insufficiency. Then, in order for the powders 4A, 4B, 4C, 4D to be supplied at the flow rates thus obtained, the powders 4A, 4B, 4C, 4D are supplied by control of the regulating valves and the like provided to the powder supply systems.

[0104]

Note that, although not shown in the present embodiment, insufficiency in the hygroscopic powder 4B containing inorganic matter supplied to the lock hopper 5 may be compensated for by equipping the above-described control device 78 with control logic for supplying the hygroscopic powder F containing inorganic matter to the feed hopper 6. Similarly, the above-described control device 78 may also be equipped with logic for setting the supply amounts of the hygroscopic powders 4G and 4H containing inorganic matter to be supplied to the feed hopper 73 of the lower burner system and the char feed hopper 26, respectively.

[0105]

As described above, based on the analysis values of the solid fuel 1, the target moisture contents in the solid fuel 1 after being dried are set, and the supply amounts of the hygroscopic powders containing inorganic matter are set so as to achieve pulverization and pneumatic conveyance of the solid fuel 1 having the target moisture contents. Further, the control device 78 includes a logical function to maintain a slag coating formed in the gasifier 19. By including such control device 78, a high-moisture solid fuel gasification system can be constructed, which achieves high energy efficiency by reducing the power for drying the solid fuel 1 and can convey the high-moisture solid fuel 1 to the gasifier 19 stably.

[0106]

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Note that the present invention is not limited to the above-described embodiments and modifications described by way of example, and the above-described embodiments and the like may be modified variously according to the design and the like without departing from the technical concept of the present invention.

[0107]

For instance, the high-moisture solid fuel 1 employed may be other than lignite (such as, e.g., low-rank coal such as subbituminous coal, biomass, or waste).

[0107a]

Throughout this specification and the claims which follow, unless the context requires otherwise, the word "comprise", and variations such as "comprises" and "comprising", will be understood to imply the inclusion of a stated integer or step or group of integers or steps but not the exclusion of any other integer or step or group of integers or steps.

[0107b]

The reference in this specification to any prior publication (or information derived from it), or to any matter which is known, is not, and should not be taken as an acknowledgment or admission or any form of suggestion that that prior publication (or information derived from it) or known matter forms part of the common general knowledge in the field of endeavour to which this specification relates.

INDUSTRIAL APPLICABILITY

[0108]

The present invention is useful as a gasification system that uses high-moisture solid fuel.

REFERENCE SIGNS LIST

[0109]

1 solid fuel

2, 2A, 2B drying device

3 pulverizing device

4A, 4B, 4C, 4D, 4E, 4F, 4G, 4H hygroscopic powder containing inorganic matter

5 lock hopper

6 feed hopper

7 solid fuel transport valve

8 inert gas

9 lock hopper pressure equalizing valve

10 feed hopper pressure equalizing valve

11 pressure regulating valve

12	solid fuel conveyance pipe
13, 13A	solid fuel burner
14	air
15	compressor
16	air separator
17	nitrogen
18	oxygen
19	gasifier
20	product gas
21	product gas cooler
22	cooled-down product gas
23	dust removing device
24	char
25	char lock hopper
26	char feed hopper
27	char transport valve
28	char lock hopper pressure equalizing valve
29	char feed hopper pressure equalizing valve
30	char system pressure regulating valve
31	water washing column
32	desulfurizing device
33	desulfurized product gas
34	product gas heat exchanger
35	product gas heater
36	first shift reactor
37	second shift reactor
38	product gas after shift reaction
39	water for shift reaction
40	heat exchanger of product gas after shift reaction and water for shift reaction
41	heat exchanger of product gas after first shift reaction and water for shift reaction
42	steam for shift reaction
43	shift reaction steam heater
44	cooler for product gas after shift reaction
45	knockout drum
46	water collected from product gas after shift reaction
47	CO_2 absorbing column

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48	product gas after CO_2 absorption
49	CO_2 absorption solution which has absorbed CO_2
50	CO_2 absorption solution heat exchanger
51	CO_2 absorption solution heater
52	CO_2 regenerating column
53	CO_2 absorption solution
54	pressure boost pump for CO_2 absorption solution
55	CO_2 absorption solution for regenerative heating
56	CO_2 absorption solution regenerative heater
57	steam for regeneratively heating CO_2 absorption solution
58	reuse CO_2 flow rate regulating valve
59	reuse CO_2 compressor
60	steam containing dispersed fuel
61	compressor
62	mist of water
63	char conveyance pipe
64	char burner
65	solid fuel supply valve
66	char supply valve
67	distributor
68	upper burner
69	solid fuel conveyance pipe leading to upper burner
70	lower burner
71	solid fuel conveyance pipe of lower burner system
72	lock hopper of lower burner system
73	feed hopper of lower burner system
74	solid fuel transport valve of lower burner system
75	lock hopper pressure equalizing valve of lower burner system
76	feed hopper pressure equalizing valve of lower burner system
77	pressure regulating valve of lower burner system
78	control device
101	collected CO_2
102	reuse CO_2
103	stored CO_2

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THE CLAIMS DEFINING THE INVENTION ARE AS FOLLOWS:

[Claim 1]

A solid fuel gasification system comprising a drying unit that dries solid fuel, a pulverizing unit that pulverizes the solid fuel, a pneumatic conveying unit that pneumatically conveys the solid fuel dried by the drying unit and then pulverized by the pulverizing unit to a gasifier, and the gasifier that gasifies the solid fuel pneumatically conveyed by the pneumatic conveying unit, wherein

the solid fuel gasification system comprises:

a powder supply system that supplies a powder which is hygroscopic and contains inorganic matter to at least one location from the pulverizing unit to the gasifier; and

a control device that finds an amount of the powder to be supplied from the powder supply system, based on a predicted evaporation amount of moisture in a place to which the powder is to be supplied.

[Claim 2]

A solid fuel gasification system comprising a drying unit that dries solid fuel, a pulverizing unit that pulverizes the solid fuel, a pneumatic conveying unit that pneumatically conveys the solid fuel dried by the drying unit and then pulverized by the pulverizing unit to a gasifier, the gasifier that gasifies the solid fuel pneumatically conveyed by the pneumatic conveying unit, a dust removing unit that separates char from a product gas produced in the gasifier and collects the char, and a char pneumatic conveying unit that pneumatically conveys the char collected by the dust removing unit to the gasifier, wherein

the solid fuel gasification system comprises:

a powder supply system that supplies a powder which is hygroscopic and contains inorganic matter to at least one location from the pulverizing unit to the gasifier and to at least one location from the char pneumatic conveying unit to the gasifier; and

a control device that finds an amount of the powder to be supplied from the powder supply system, based on a predicted evaporation amount of moisture in a place to which the powder is to be supplied.

[Claim 3]

A solid fuel gasification system comprising a drying unit that dries solid fuel, a pulverizing unit that pulverizes the solid fuel, a pneumatic conveying unit that pneumatically conveys the solid fuel dried by the drying unit and then pulverized by the pulverizing unit to a gasifier, the gasifier that gasifies the solid fuel pneumatically conveyed by the pneumatic conveying unit, and a dust removing unit that separates char from a product gas produced in the gasifier and collects the char, the solid fuel gasification system supplying the char collected by the dust removing unit to the pneumatic conveying unit to pneumatically convey the char to the gasifier along with the solid fuel, wherein

the solid fuel gasification system comprises:

a powder supply system that supplies a powder which is hygroscopic and contains inorganic matter to at least one location from the pulverizing unit to the gasifier; and

a control device that finds an amount of the powder to be supplied from the powder supply system, based on a predicted evaporation amount of moisture in a place to which the powder is to be supplied.

[Claim 4]

The solid fuel gasification system according to any one of claims 1 to 3, wherein

the pneumatic conveying unit has a fuel hopper, and

the powder supply system supplies the powder to each of the pulverizing unit and the fuel hopper individually.

[Claim 5]

The solid fuel gasification system according to claim 2, wherein

the pneumatic conveying unit has a fuel hopper,

the char pneumatic conveying unit has a char hopper, and

the powder supply system supplies the powder to each of the pulverizing unit, the fuel hopper, and the char hopper individually.

[Claim 6]

The solid fuel gasification system according to claim 4 or 5, wherein

the drying unit has a first drying unit and a second drying unit,

the pulverizing unit pulverizes the solid fuel dried by the first drying unit,

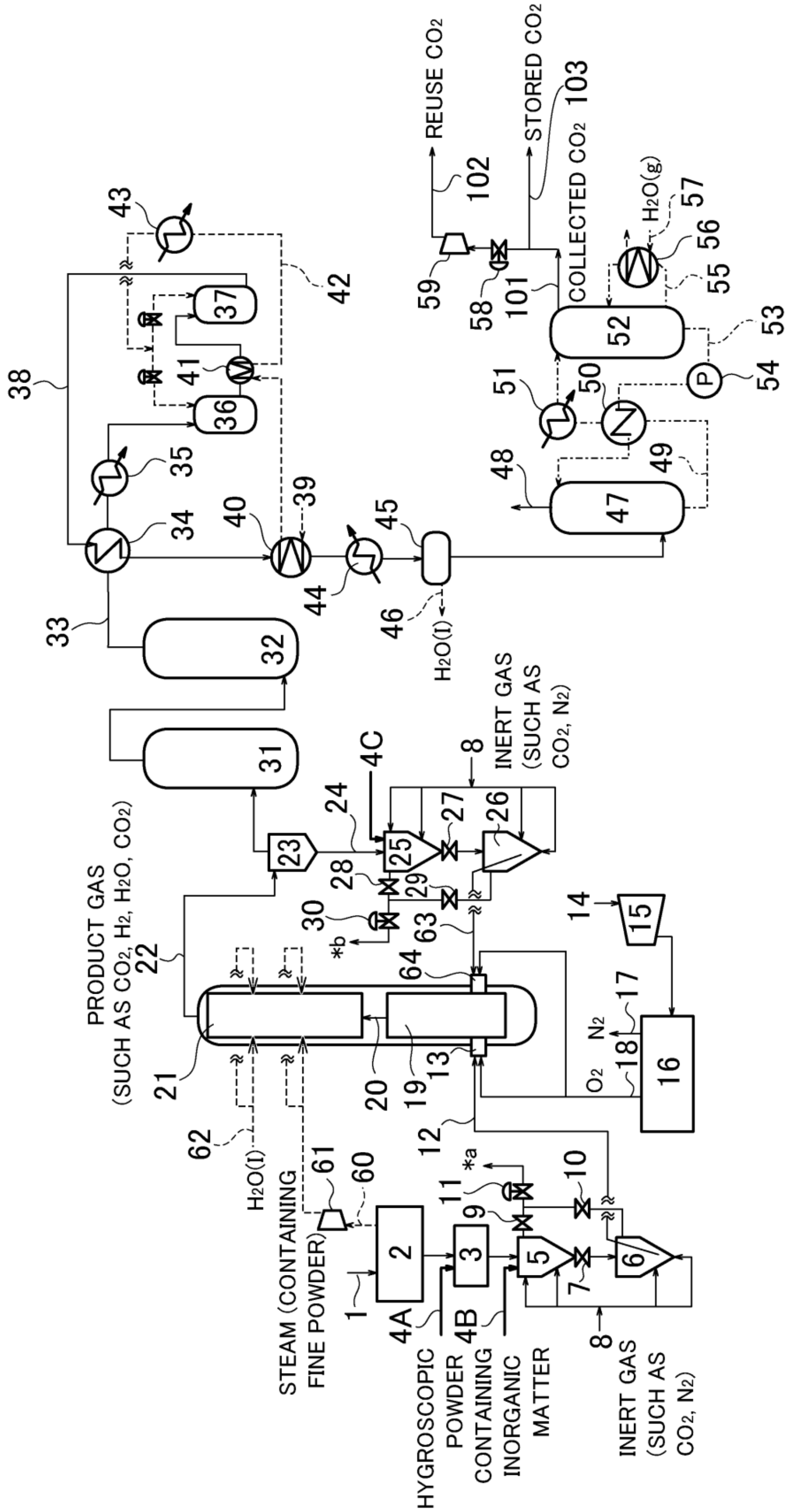
the second drying unit dries the solid fuel pulverized by the pulverizing unit,

the pneumatic conveying unit is provided with an upper burner pneumatic conveyance system that supplies the solid fuel pulverized by the pulverizing unit to an upper burner of the gasifier and a lower burner pneumatic conveyance system that supplies the solid fuel pulverized by the pulverizing unit to a lower burner of the gasifier,

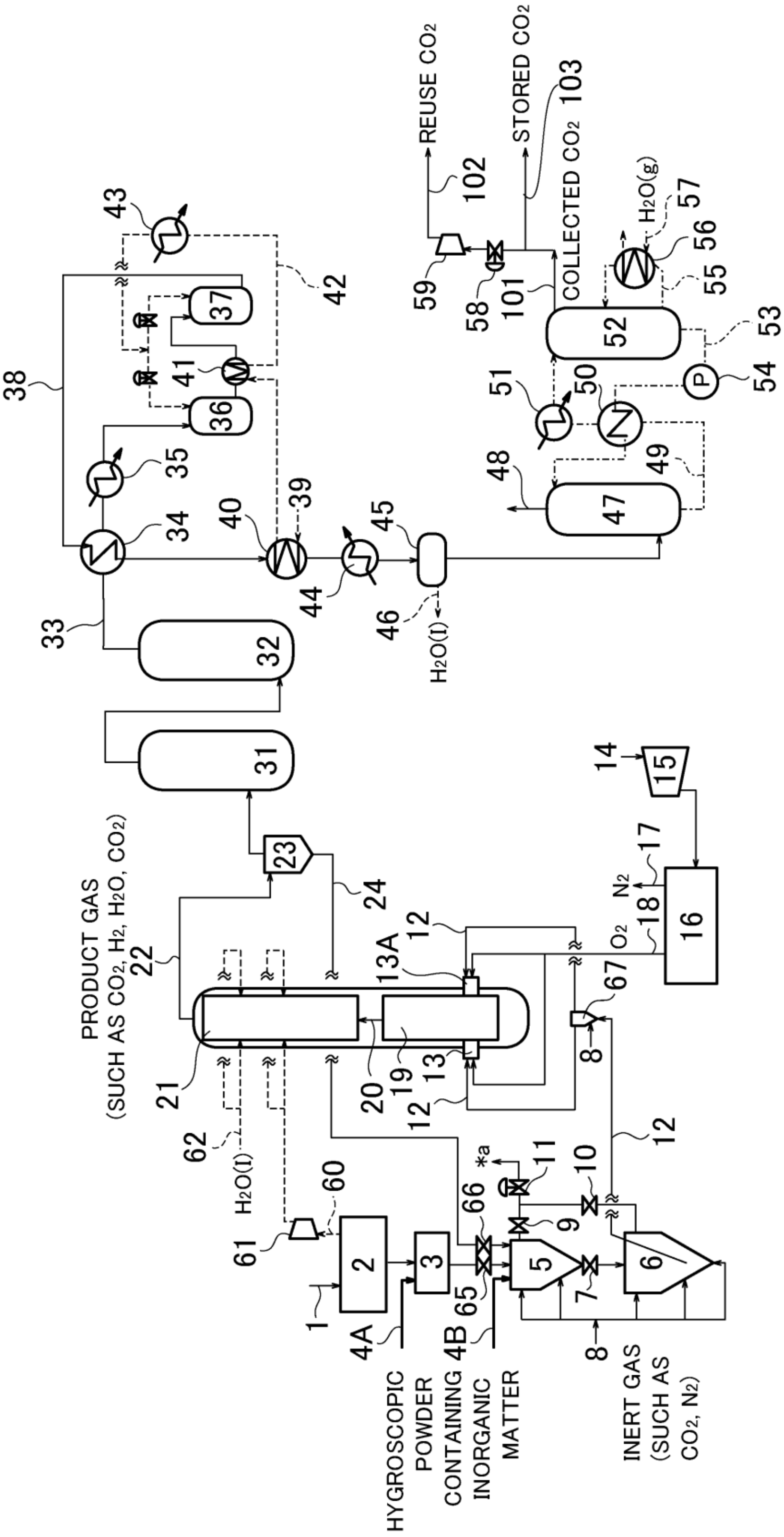
the fuel hopper includes an upper burner hopper provided to the upper burner pneumatic conveyance system and a lower burner hopper provided to the lower burner pneumatic conveyance system, and

the powder supply system supplies the powder to each of the upper burner hopper and the lower burner hopper individually.

[Fig. 1]


REUSE CO_2
STORED CO_2
COLLECTED CO_2
H_2O(g)
H_2O(l)
PRODUCT GAS (SUCH AS CO_2, H_2, H_2O, CO_2)
INERT GAS (SUCH AS CO_2, N_2)
STEAM (CONTAINING FINE POWDER)
HYGROSCOPIC POWDER CONTAINING INORGANIC MATTER
O_2
N_2
*a
*b
P

[Fig. 2]


REUSE CO2
STORED CO2
COLLECTED CO2
PRODUCT GAS
(SUCH AS CO2, H2, H2O, CO2)
H2O(l)
H2O(g)
O2
N2
*a
P
HYGROSCOPIC POWDER CONTAINING INORGANIC MATTER
INERT GAS (SUCH AS CO2, N2)
1
2
3
4A
4B
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9
10
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12
13
13A
14
15
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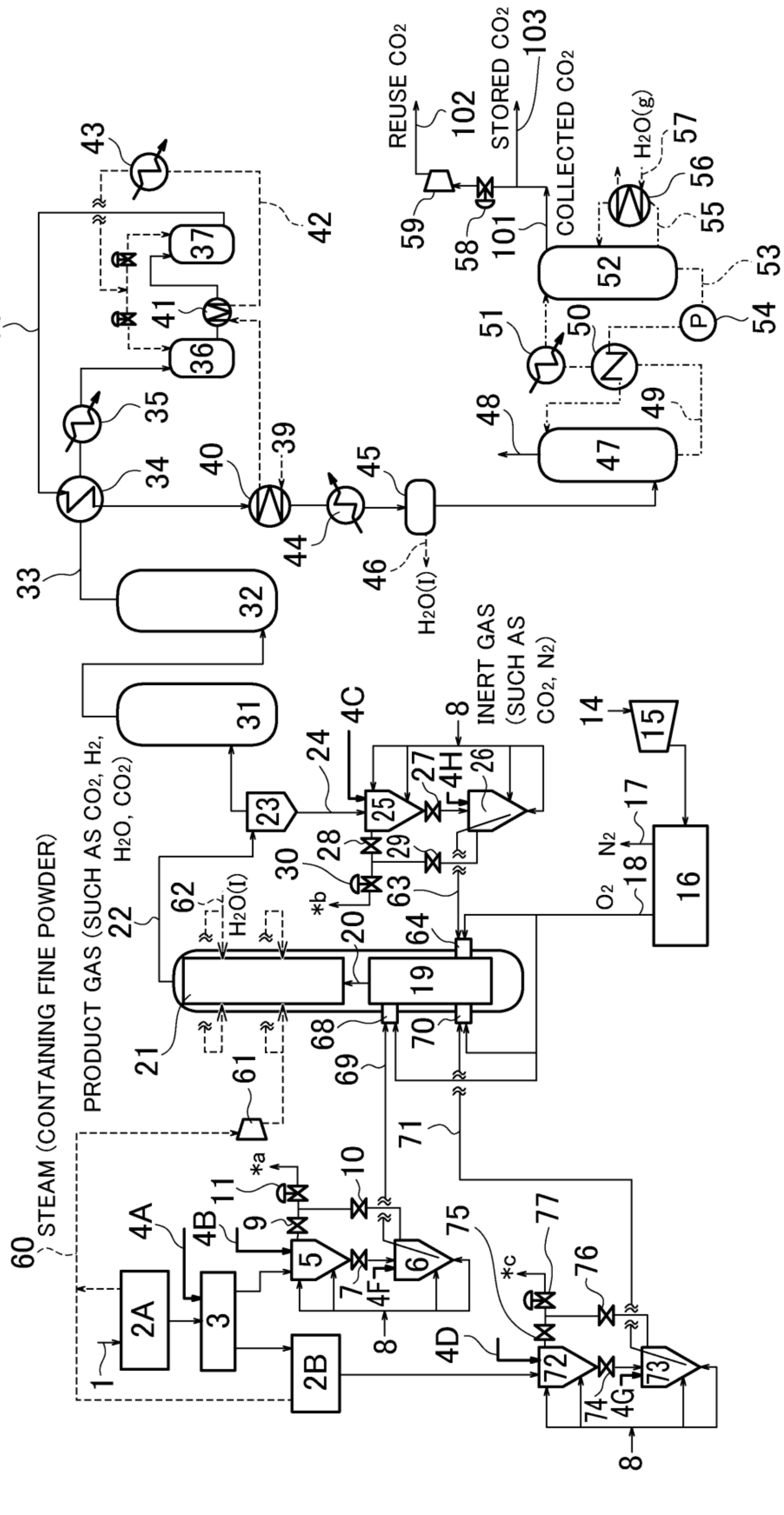
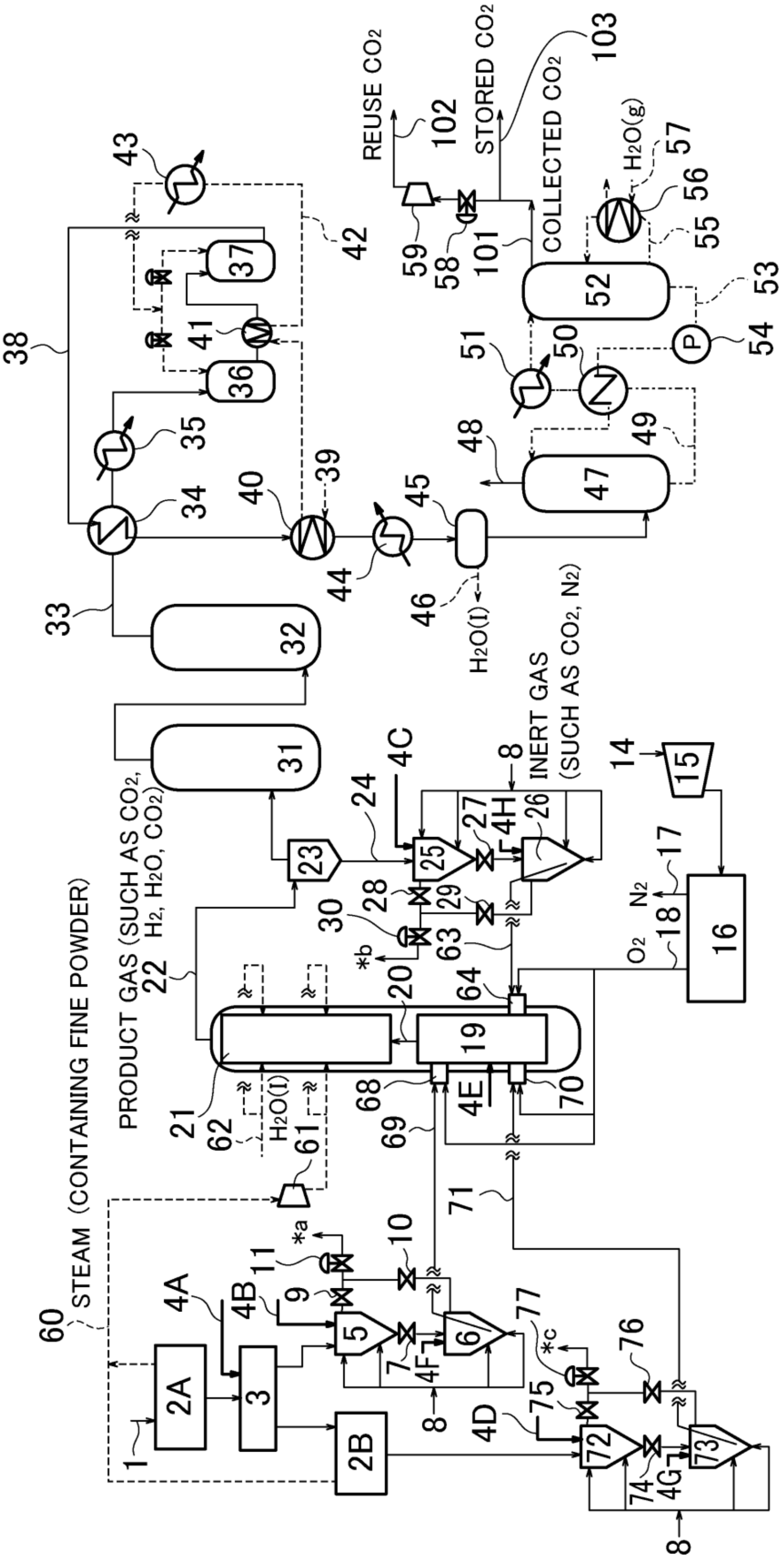
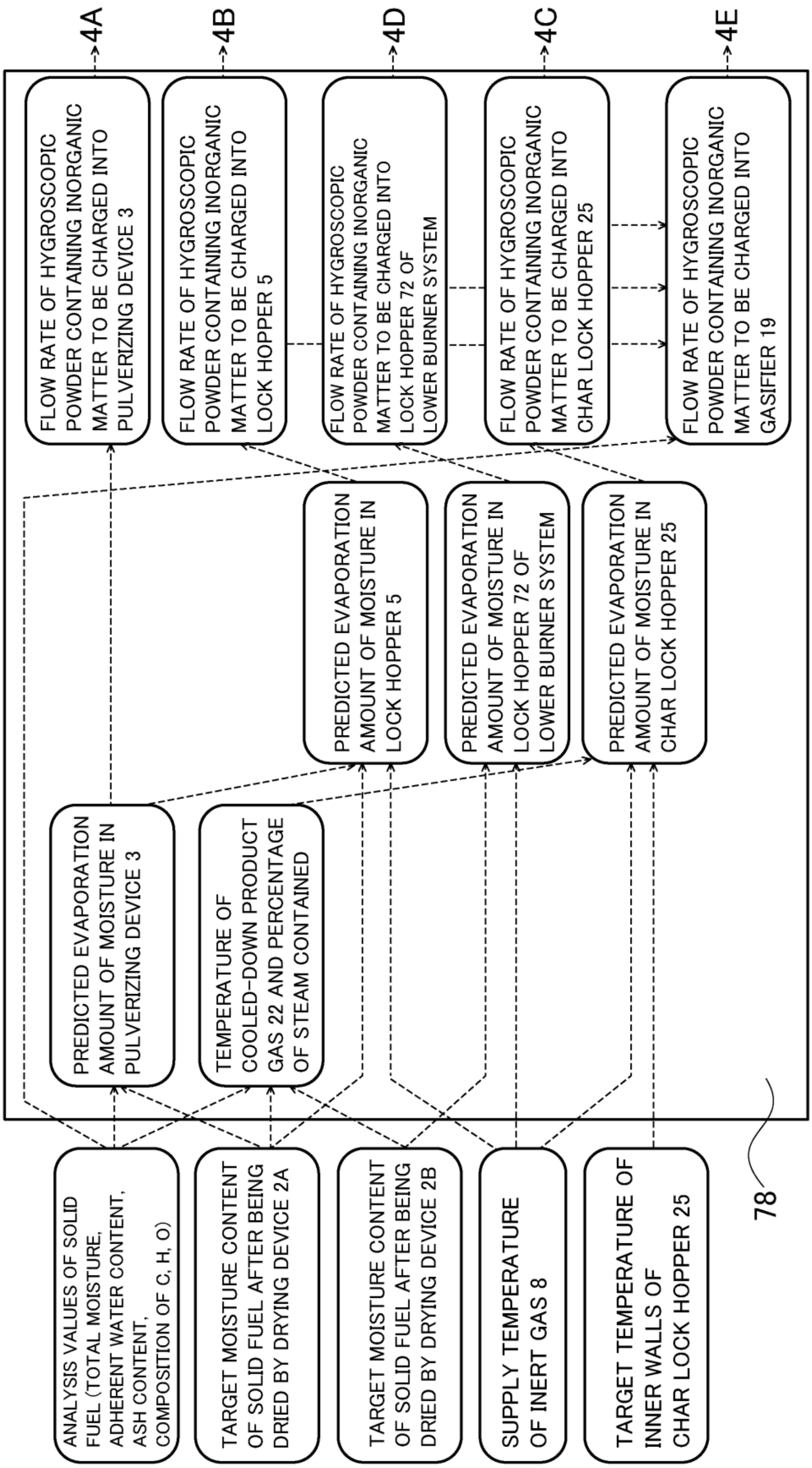
[Fig. 3]


STEAM (CONTAINING FINE POWDER)
PRODUCT GAS (SUCH AS CO2, H2, H2O, CO2)
H2O(l)
INERT GAS (SUCH AS CO2, N2)
O2
N2
REUSE CO2
STORED CO2
COLLECTED CO2
H2O(g)
*a
*b
*c

[Fig. 4]


STEAM (CONTAINING FINE POWDER)
PRODUCT GAS (SUCH AS CO_2, H_2, H_2O, CO_2)
H_2O(l)
INERT GAS (SUCH AS CO_2, N_2)
O_2
N_2
REUSE CO_2
STORED CO_2
COLLECTED CO_2
H_2O(g)
*a
*b
*c
P

[Fig. 5]


ANALYSIS VALUES OF SOLID FUEL (TOTAL MOISTURE, ADHERENT WATER CONTENT, ASH CONTENT, COMPOSITION OF C, H, O)
TARGET MOISTURE CONTENT OF SOLID FUEL AFTER BEING DRIED BY DRYING DEVICE 2A
TARGET MOISTURE CONTENT OF SOLID FUEL AFTER BEING DRIED BY DRYING DEVICE 2B
SUPPLY TEMPERATURE OF INERT GAS 8
TARGET TEMPERATURE OF INNER WALLS OF CHAR LOCK HOPPER 25
78
PREDICTED EVAPORATION AMOUNT OF MOISTURE IN PULVERIZING DEVICE 3
TEMPERATURE OF COOLED-DOWN PRODUCT GAS 22 AND PERCENTAGE OF STEAM CONTAINED
PREDICTED EVAPORATION AMOUNT OF MOISTURE IN LOCK HOPPER 5
PREDICTED EVAPORATION AMOUNT OF MOISTURE IN LOCK HOPPER 72 OF LOWER BURNER SYSTEM
PREDICTED EVAPORATION AMOUNT OF MOISTURE IN CHAR LOCK HOPPER 25
FLOW RATE OF HYGROSCOPIC POWDER CONTAINING INORGANIC MATTER TO BE CHARGED INTO PULVERIZING DEVICE 3
FLOW RATE OF HYGROSCOPIC POWDER CONTAINING INORGANIC MATTER TO BE CHARGED INTO LOCK HOPPER 5
FLOW RATE OF HYGROSCOPIC POWDER CONTAINING INORGANIC MATTER TO BE CHARGED INTO LOCK HOPPER 72 OF LOWER BURNER SYSTEM
FLOW RATE OF HYGROSCOPIC POWDER CONTAINING INORGANIC MATTER TO BE CHARGED INTO CHAR LOCK HOPPER 25
FLOW RATE OF HYGROSCOPIC POWDER CONTAINING INORGANIC MATTER TO BE CHARGED INTO GASIFIER 19
4A
4B
4D
4C
4E