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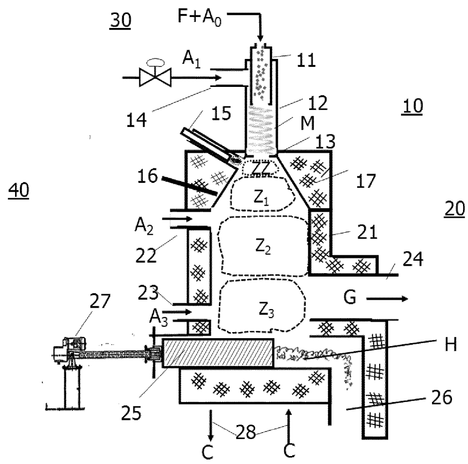
(54) **BURNER DEVICE AND COMBUSTION DEVICE**

(57) A powder burner device which can utilize a coarsely pulverized biomass powder as an industrial fuel and a combustion furnace which can be operated stably and efficiently by using the burner device are disclosed. The powder burner device 10 in this application comprises a burner tube 12, a fuel supply device 30 that supplies a biomass powder F to the burner tube 12, and a primary air supply pipe 14 connected to the side wall of the burner tube 12, wherein the biomass powder F supplied from the fuel supply device 14 falls within the burner tube 12 while being swirled by the primary air supplied from the primary air supply pipe and is discharged from a fuel discharge port 13 at a lower end of the burner tube 12. The powder burner device 10 further includes a heat insulating wall 17 having a conical inner wall 17a provided below the fuel discharge port 13.

Fig. 1



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Description

TECHNICAL FIELD

[0001] The present application relates to a burner device and a combustion apparatus using biomass powder such as grass, wood, food waste, etc. as a fuel. The present application discloses a powder burner device which can utilize even a coarsely pulverized (or grind, cut) biomass powder as an industrial fuel, and further discloses a combustion furnace using the burner device which can be operated stably and efficiently. The biomass powder combustion apparatus of the present application can use grass such as rice straw, wheat straw, rice hulls, and yoshi, wood books such as thinned wood, wood waste, construction waste, bark and pruned branches as an industrial fuel capable of the combustion control. It can also use a solid flame-retardant biomass such as coffee slag, waste flooring, and food residue, even if the biomass is non-easy-flammable biomass such as low calorific value, high ash content, or low melting point ash. The combustion apparatus of the present application can be utilized as an alternative apparatus such as an existing oil/gas fuel combustion apparatus in addition to a heat source apparatus and a power generation plant.

BACKGROUND

[0002] The reason why various types of biomass exist but have not been used widely is that they have not been used in a lumped amount as industrial fuels. If it can be used as an industrial fuel, it becomes valuable energy. In order to be used as a fuel for an industrial combustion apparatus, it is important to be able to control the combustion amount, the combustion exhaust gas temperature, the exhaust gas property, and the like as a heat source in a short time (in minutes) as in the case of gas and petroleum fuels. In a combustion apparatus using biomass as a fuel, there is no other system that can satisfy this condition than a burner type. In the case of the burner type, the combustion amount can be instantaneously controlled by the supply amount of the fuel powder, the combustion exhaust gas temperature and the exhaust gas property can also be instantaneously controlled by the amount of the combustion air, and the burner device can function as a combustion apparatus of an industrial heat source. However, at present, a powder type combustion apparatus which uses biomass powder as a fuel and can be used for a general purpose has not been developed.

[0003] In the present application, a burner device is a type in which fuel and air are discharged from a fuel discharge port and ignition and flame holding are performed in the vicinity of the discharge port, and a device such as an incinerator that maintains combustion by using a combustion furnace as a whole, fuel is combusted in a furnace only and no flame is formed and discharged from the vicinity of the fuel discharge port, is not called a burner device.

[0004] One of the best systems for industrial use of powdered fuels is the powder burner system. The powder burner type apparatus is almost 100% used in commercial coal-fired large boilers. The most important point of the powder burner type apparatus is that ignition and flame holding can be carried out at the fuel discharge port. Therefore, in a powder burner device using coal as a fuel, pulverized coal of ultrafine powder of 75μm or less is generally used. On the other hand, biomass has a large amount of fibrous matter, requires a large amount of pulverizing power to be pulverized, and in some cases consumes power equal to or more than the amount of raw material heat, resulting in an increase in cost and cannot be used as an industrial fuel.

[0005] Conventionally, a stoker type combustion apparatus using a moving bed or a fixed bed type grate is a mainstream of a combustion apparatus using biomass in the form of chips and powders as a fuel. In these combustion apparatuses, biomass processed into chips, pellets, or the like is used. Although the stoker type is widely used in incinerators, it is difficult to control the combustion amount and combustion temperature in order to use it as a heat source for industrial use, and it is not used as a heat source device for industrial use. Furthermore, in the case of a grate typy, the amount of combustible fuel is proportional to the area of the grate. Therefore, when the gaseous combustion region in the downstream portion of the grate is included, the combustion space becomes excessively large as that of the incinerator, and cannot be used as an industrial heat source device. On the other hand, various methods for using biomass as a heat source have been proposed, but there are few methods that can be used as a general-purpose heat source for industrial use, and various prior arts to be described later also have drawbacks.

[0006] In the conventional up-draft stoker type biomass combustion apparatus using a grate which is used for woody biomass, the approximate dimensions of the apparatus for a combustion quantity of 100kg/h class can be calculated as follows:

- Combustion quantity: 100 kg/h (based on 20% water-containing biomass)
- Combustion calorific value: 1.5×10^{6} (low calorific value standard)kJ/h
- Grate area: $1.2m^2$
- Dimensions in the combustion apparatus: Vertical 1.1m × Horizontal 1.1m × Height 7.5m
- Combustion-zone volume: $9m^3$
- Furnace loading, indicating the performance of the combustion apparatus: 1.5×10^{6} $kJ/h/9m^3$ = $167{,}000kJ/m^3h$=$40{,}000kcal/m^3h$

[0007] Since the furnace load is about 1/10 of that of the combustion apparatus of the present application, which will be described later, the apparatus volume is 10 times larger. This is too large as a heat source apparatus for industrial use so, it is difficult to use as a practical use.

[0008] The basic design dimensions of a conventional 100kg/h stoker type wood biomass combustion apparatus using a grate were discussed above, but this combustion apparatus not only has too large size but also has the following disadvantages in terms of performance.

(1) In stoker-type combustion, ignition combustion on the upper surface of the grate causes partial combustion of the fuel and generation of pyrolysis gas. To complete combustion, OFA (over-fire air) is blown into a downstream portion, but it is difficult to uniformly mix the combustion gas and air with each other, and unburned gas is easily left.

(2) In stoker-type combustion, it is difficult to increase the combustion gas temperature by increasing the volume of the combustion furnace and by using OFA. In general, the temperature of the combustion gas at the combustion furnace outlet remains between 800 and 900° C and cannot provide a high-temperature heat sources exceeding 1000° C.

(3) The amount of OFA air is usually 30 to 40% of the total amount of air blown into the combustion apparatus, but it is necessary to increase OFA in order to thoroughly to be mixed with the combustion gas, so the combustion temperature is lowered and combustion is inhibited.

(4) Since the combustion on the grate is affected by the stacking state of the fuel chips, the combustion state is easily changed over time, and it is difficult to be used as an industrial heat source.

(5) As described above, it is difficult to completely burn the unburned content in the combustion gas, and the combustion exhaust gas containing carbon and hydrocarbons is discharged after heat utilization, and thus a purification device is required.

(6) The biomass usually includes a saline. Therefore, the combustion gas contains chlorine (CL_2) and tends to generate dioxins having a strong toxicity.

(7) Dioxin generated on the surface of the grate is said to be decomposed by holding the combustion gas at the outlet of the combustion furnace at 800° C or more for 2 seconds or more, but dioxin is generated by a reaction called de novo synthesis in a low temperature range of 600 to 250° C when the temperature drops by heat utilization of the thermal firing gas.

(8) Dioxin is a chemical combination of chlorine gas and hydrocarbon, is highly toxic, and little emission is not permitted. The dioxin-concentration regulation of exhaust gas is very strict to 0.1ng-TEQ/m^3. (Note: 1 ng = 10^{-9}g, TEQ is the sum of the conversion values of various dioxins.)

[0009] It can be seen from the above description that the use of biomass as an industrial fuel in a stoker-type combustion apparatus, which is commonly used in general, has many problems.

[0010] In recent years, a combustion apparatus using biomass as a fuel and which can be used as an industrial heat source has been developed. For example, Patent Document 1 discloses a system in which solid biomass is pulverized to an average particle size of 300μm or less and used as a general fuel. The pulverization makes the biomass more handleable, more ignitable and combustible, and can be used as a fuel for a combustion apparatus. However, it is said that the power and energy required for pulverization increases in proportion to the surface area of the pulverized material after pulverization, and the power required for pulverization having an average particle diameter of 300μm or less is several tens to several hundreds times more expensive than that of general medium to coarse pulverization, and in some cases, exceeds the amount of raw material heat, which makes the biomass difficult to be used as an industrial fuel.

[0011] Technological development is underway to utilize rice hulls, which are generated as enormous agricultural byproducts every year, as biomass fuel. The annual production of rice hulls in Japan alone is 1.7 million tons, equivalent to 500,000 tons of oil, which is a valuable resource as a renewable energy source. However, rice hulls are difficult to ignite, have a smoke-prone property, and are difficult to use because they are fuels belonging to flame retardancy substance. Since rice hulls have a size corresponding to rough grinding of about 10mm in size, a method of compression molding and using them as pellets, a method of using them as coal, or the like has been put into practical use, but there is a disadvantage that the production cost is too high in terms of industrial heat source fuel.

[0012] The use of rice hulls has also been promoted as an industrial fuel, and in recent years, the rice hull power generation business has been developed in Southeast Asia. The Rankine cycle system for boilers and steam turbines and the gasification engine power generation system are available as power generation systems. However, because of the flame retardancy of rice hulls, both combustion and gasification systems are equipped heavily, and operating power costs are high. As a combustion system, air spraying type traveling stoker system, air blowing type stirred fluidized bed combustion furnace, fluidized bed combustion furnace for low temperature combustion, etc. are in practical use or development, and as a gasification system, updraft grate partial combustion gasification system, external heat kiln gasification system, etc. are in practical use or development. Both of these systems, as well as the equipment cost, are expensive to operate and improvement is required from the industrial demand.

[0013] While Patent Document 1 is a technique for improving combustibility by pulverizing solid biomass, Patent Document 2 discloses a combustion apparatus that utilizes medium to coarse (several hundred microns to several centimeters) biomass powder, which can be produced at low cost, as fuel. A powder of agar powder or rice hulls is used as a fuel biomass powder, and in the system, a combustion chamber is provided at the bottom of the system, the fuel of powder and combustion air are blown into the combustion chamber, the combustion gas is cyclone-combusted by a swirling flow of air, and the combustion gas is sent to the secondary combustion chamber, and the water cooling pipe constituting the peripheral wall of the secondary combustion chamber is heated to discharge the exhaust gas to the outside of the system. This system only heats the hot water or the steam in the heat exchanger integrated into the apparatus and can not be used as a general purpose combustion apparatus. In addition, since ash brought in by fuel is conveyed and discharged by combustion gas, it is necessary to keep the velocity of the hollow cylinder in the combustion furnace (space average gas flow velocity) equal to or higher than the terminal velocity of the ash particles (velocity at which the dropping of the particles stops), high-load combustion, which is a high efficiency condition, cannot be attained. In addition, it is impossible to change the operating conditions other than the planned operating conditions, and it is difficult to use them for general purposes.

[0014] Patent Document 3 discloses a powder fuel combustion burner using powder biomass as a fuel. However, the distal end portion of the fuel supply pipe of this apparatus does not have an ignition function as a burner, and is only a combustion furnace of a lateral cylindrical pipe, and is not a burner device as referred to in the present application. Further, the ignition means provided at the inlet of the apparatus has a problem in terms of cost in that an energy source other than biomass such as gas, liquid fuel, electric spark, or the like is constantly used during operation.

[0015] Although Patent Document 4 has a function as a biomass powder burner, it has drawbacks such as 1) to 5) described below.

1) Flame holding function is insufficient when flame-retardant powder such as rice hulls is used as fuel.
2) In the case of the flame-retardant powder, it is difficult to adjust the primary air amount for ignition stability.
3) The particle diameter of the powder is assumed to be medium crushed powder (3mm or less), and stable ignition and flame holding are difficult when coarsely pulverized powder particles of several cm class are included.
4) When grass-based biomass having a high ash content of 5 to 20% is used as a fuel, there are problems in ignition and flame holding.
5) In the case of weeds and other grassy biomass, the content of low-melting-point ash is high, and clinker can not be prevented.

[Prior Arts]

[PATENT LITERATURE]

[0016]

Patent Literature 1: Japanese Unexamined Patent Application Publication No. 2008-13738

Patent Literature 2: Japanese Unexamined Patent Application Publication No. 2010-185631

Patent Literature 3: Japanese Unexamined Patent Application Publication No. 2011-7478

Patent Literature 4: Japanese Unexamined Patent Application Publication No. 2014-206346

SUMMARY OF THE INVENTION

[0017] Although biomass fuels are expected to be used as renewable energy, their use is limited to a narrow range. Only wood chips are commonly used as industrial fuels. This is because white wood is a high-quality fuel containing very little ash, chlorine, nitrogen, and the like which hinder combustion. It is the current state that most of the biomass having problems of flame retardancy, high ash content and low calorific value, such as bark, pruned branches, rice hulls, food waste, rice hulls, weeds, etc. are incinerated.

[0018] The various types of biomass mentioned above are also valuable renewable energy feedstock, and if they can be used as industrial fuels, not only a low cost heat source can be obtained, but at the same time incineration processing costs can be reduced.

[0019] In order to use a combustion apparatus using combustion gas as a heat source for industrial use, in addition to low pollution, it is necessary to have the same degree of controllability as a combustion apparatus for petroleum and gas fuels. For example, it is required that the control of the combustion amount, the combustion exhaust gas temperature, the exhaust gas property, and the like can be performed in a short time (in units of minutes).

[0020] The best system for using a solid fuel for industrial use is a powder burner system, and almost 100% of commercial coal-fired large boilers employ the powder burner system. In this system, since it is necessary that the pulverized fuel can be ignited and a flame has to be kept at the fuel discharge port, pulverized coal with ultrafine particles of 75μm or less is used. On the other hand, biomass raw material generally contains a large amount of fibrous material, and if it is ultra-fine-pulverized, the pulverizing power exceeds the heat value of the product powder, and the price is out of the range for the industrial use.

[0021] The goal of the present invention is to realize a biomass powder combustion apparatus that can utilize a wide variety of solid biomass as an industrial fuel without excessive milling costs. The combustion apparatus of the present application has a configuration in which a powder burner device and a combustion furnace are connected, and all or some of the following requirements (1) to (8) are achieved.

(1) In the powder burner system, ignition and flame holding are stably maintained in the vicinity of the fuel discharge port without assisted combustion by gas and liquid fuels, even when a coarsely pulverized powder biomass is used.
(2) The load (combustion amount) can be changed (controlled) within a short time (in minutes).
(3) The temperature of the combustion gas at the outlet of the combustion furnace shall be controllable in accordance with the change in load.
(4) Do not cause clinker troubles even when low melting point ash fuel is used.
(5) Even with a fuel with high ash content, ash can be discharged outside the system without problems.
(6) The size (volume) of the combustion apparatus is more compact than that of the chip combustion unit.
(7) Combustion exhaust gas can be controlled to clear regulation standards.
(8) Even if the fuel contains chlorine, dioxin can be suppressed below the regulated standard value.

MEANS FOR SOLVING THE PROBLEM

[0022] In this application, inventions having the aspects below are disclosed.

<Constitution 1 >

[0023] A powder burner device comprising:

a burner tube,
a fuel supply device that supplies biomass powder to the burner tube, and
a primary air supply pipe connected to the side wall of the burner tube, wherein;
a biomass powder supplied from the fuel supply device falls within the burner tube while being swirled by the primary air supplied from the primary air supply pipe and is discharged from a fuel discharge port at a lower end of the burner tube, characterized in that;
a heat insulating wall having a conical inner wall is provided below the fuel discharge port.

<Constitution 2>

[0024] A burner device according to constitution 1, wherein a spreading solid angle of the conical inner wall is 3.5 steradian or less.

<Constitution 3>

[0025] A burner device according to constitution 1 or 2, wherein the biomass powder has a maximum particle size of 30mm or less and contains 10% by weight or more of a biomass powder having a particle size of 0.5mm or less.

<Constitution 4>

[0026] A burner device according to any one of constitutions 1 to 3, further comprising a primary air control means for controlling the temperature and supply amount of the primary air so that the temperature of the conical inner wall is kept at 900°C or higher.

<Constitution 5>

[0027] A combustion furnace comprising:

a burner device according to any one of constitutions 1 to 4 and
a combustion furnace directly connected to a lower part of the burner device.

<Constitution 6>

[0028] A combustion furnace of constitution 5, wherein said combustion furnace comprises:

a primary combustion zone downstream of the fuel supply port,
a secondary combustion zone downstream of the primary combustion zone for main combustion by a secondary air blown into the secondary combustion zone,
a tertiary combustion zone downstream of the secondary combustion zone for combusting an unburned content by a tertiary air blown into the tertiary combustion zone, and
a secondary air control means and a tertiary air control means for controlling the supply amounts of the secondary air and the tertiary air.

<Constitution 7>

[0029] A combustion furnace according to constitution 5 or 6, further comprising an ash removal device for removing a combustion ash accumulated on a bottom surface of the furnace to outside of the system.

[0030] In the powder burner device of Configuration 1 of the present application, the ignition and flame holding properties of the biomass were remarkably improved by using both of a method in which the biomass powder was dropped to the fuel discharge port in the burner tube and a method in which the biomass powder was swirled in the burner tube, and by providing a heat insulating wall having a conical inner wall below the fuel discharge port.

[0031] The temperature of the conical inner wall can be controlled by the supply amount, the temperature, etc. of the primary air. By forming the shape of the inner wall of the heat insulating wall into a conical shape, a wide region of the inner wall can be kept at a high temperature, for example, 900° C or more. By this effect, the ignition and flame holding properties of the biomass powder are improved, the required inner wall area can be reduced, the distance from the inner wall surface to the fuel discharge port can be shortened, or the combustion furnace can be manufactured compactly at low cost.

[0032] In a preferred embodiment, the burner device is capable of ignition and flame holding without the use of gas or liquid fuel. In addition, since the burner type device is the best combustion method for use as an industrial heat source, the combustion apparatus can have a configuration in which a combustion furnace is directly connected to a lower portion of the burner device.

[0033] By employing the method of burning powder, it is possible to easily control the combustion amount, the combustion furnace outlet temperature (target utilization temperature), and the exhaust gas property (no pollution), and the control time can be made as short as necessary (in minutes).

[0034] In the above-mentioned powder burner device, grass, wood, agricultural byproducts, food residue, and the like can be used as biomass powder fuel. In particular, it is possible to use a flame-retardant biomass such as rice hulls and a biomass having high ash content or having low melting point ash such as weeds, and it is also possible to use a biomass having a high moisture content (about 30% by weight).

[0035] The powder particle size is roughly classified to a coarse pulverization ("several cm), medium pulverization (several hundred μ to several mm), fine pulverization (several tens to hundreds μ), and ultra-fine pulverization (upto several tens μ). The particle size in this application is based on mesh opening size. Particle size is measured in accordance with the JIS General Rules Z8815 Mesh Screen Test Methods. Since the powder having a high moisture content tends to be agglomerated, it was dried to about 10% moisture content and measured in a powder like state.

[0036] When the primary air becomes excessive, ignition and flame holding become difficult. Therefore, the supply amount of the primary air needs to be equal to or less than the theoretical air amount (theoretical stoichiometry) of the biomass powder. The weight ratio (air/fuel) of the theoretical air amount of the biomass powder to the biomass fuel (dry basis) is 5 to 6. In normal combustion, an air amount of 1.5 to 2.5 times the theoretical air amount is used for combustion.

[0037] The fuel supply device preferably supplies the biomass powder to the burner tube by using the conveying air having a weight of 2 to 4 times of the biomass powder(40 to 60% of the theoretical air amount), and if this concentration is used, stable ignition at the discharge port of the burner tube is easily obtained, and the combustion amount can be changed in a short time (in minutes).

[0038] In the powder burner device, stable ignition at the burner tube discharge port is most important, and therefore, the balanced control of the powder concentration by the powder fuel supply amount and the primary air supply amount is indispensable, but by setting the temperature of the primary air to 150° C or more, the ignition of the high moisture flame retardant biomass fuel is also improved.

[0039] It is preferable that the combustion furnace has a primary combustion zone, a secondary combustion zone downstream of the primary combustion zone for main combustion by a secondary air blown into the secondary combustion zone, a tertiary combustion zone downstream of the secondary combustion zone for combusting an unburned content by a tertiary air blown into the tertiary combustion zone, and a secondary air control means and a tertiary air control means for controlling the supply amounts of the secondary air and the tertiary air. By controlling the supply amounts of the secondary and tertiary air, it is possible to control the combustion exhaust gas temperature, the exhaust gas properties, and the like in a short time (in minutes) and/or to clear the exhaust gas regulation standard.

[0040] By setting the combustion temperature in the combustion furnace to 800 to 1200° C, it is possible to obtain a combustion exhaust gas clearing the regulation standard value with leaving almost no unburned gas, particularly hydrocarbons. Even if the raw material contains chlorine, since the residence time at the combustion temperature of 800° C or more is set to 2 seconds or more, dioxin, if any, can be decomposed between the combustion zone and the combustion furnace outlet, and the unburned content of hydrocarbons in the combustion exhaust gas becomes close to zero, so that the de novo reaction does not occur. Therefore, dioxin can be suppressed to be equal to or lower than the exhaust gas regulation standard value.

[0041] As the temperature of the industrial heat source, high temperature of 800 to 1200° C is required in many cases, and when the temperature at the combustion furnace outlet is controlled to this temperature range, ash slag is generated in the combustion furnace if a biomass fuel of low melting point ash of 1000° C or less is used, a trouble due to clinker or the like may occur. For this reason, limestone, slaked lime, dolomite, and the like are mixed into the fuel before combustion as the ash melting point raising agent to prevent ash slag. In this case, the mixing cost of the ash melting point raising agent as well as the processing cost of the discharged ash are increased, which is a problem in operation.

[0042] In the present invention, in the case of using a low melting point ash fuel, cooling means for cooling the furnace bottom can be provided. This causes the combustion ash to adhere in a molten or softened state to the furnace wall of the combustion furnace and to descend to the furnace bottom where it coagulates or solidifies. The coagulated or solidified combustion ash is discharged out of the system by a pusher. This can prevent the clinker (solidified ash) from being fixed. The furnace wall of the combustion furnace may have a softening point temperature, e.g., 600° C, and the temperature of the furnace bottom may be less than or equal to the softening point temperature. The swirling flow of primary, secondary and/or tertiary air may be generated to facilitate the adherence of combustion ash in a molten or softened state to the furnace wall. By having a cooled furnace bottom, low melting point ash fuel can also be used as industrial fuel.

[0043]

[Figure 1] An overall view of a biomass powder combustion apparatus 40 according to one embodiment of the present invention is shown.

[Figure 2] A powder burner apparatus 10 is shown. (A) is a schematic view from the side, and (B) is a schematic view from the top.

[Figure 3] A powder fuel supply device 30 is shown.

[Figure 4] An example of the arrangement of the conical inner wall 17a, the fuel discharge port 13, and the flame holding plate 13a are shown.

[Figure 5] An ash discharge unit of the combustion furnace 20 is shown.

[Figure 6] The particle size distribution of the test biomass powders F1 to F3 used for the experiment in the demonstration experiment apparatus is shown.

[Figure 7] A stable ignition range of cedar powder F1 is shown.

[Figure 8] A stable ignition range of rice husk powder F2 is shown.

[Figure 9] Astable ignition range of weed and pruned branch powder F3 is shown.

MODE FOR CARRYING OUT THE INVENTION

[0044] FIG. 1 shows an overall view of a combustion apparatus 40 of one embodiment of the present invention. The combustion apparatus 40 includes a burner device 10 and a combustion furnace 20 directly connected to a lower portion of the burner device 10. The biomass powder F is supplied from the fuel supply device 30 to the burner device 10.

[0045] FIG. 2 shows the burner device 10. The burner device 10 includes a fuel supply pipe 11 connected to a fuel supply device 30, a burner tube 12 having a fuel discharge port 13 formed at a lower end thereof, a primary air supply pipe 14 connected to a side wall of the burner tube 12, and a heat insulating wall 17 located below the burner tube 12. It is preferable that the periphery of the fuel discharge port 13 is covered with a heat insulating wall 17, and the inner space of the burner tube 12 and the inner space of the heat insulating wall 17 are directly connected to each other.

[0046] FIG. 3 illustrates an exemplary fuel supply 30. The fuel supply device 30 includes a fuel transport pipe 31, a hopper 32, and a screw feeder 34 driven by a motor 33. The biomass powder F is transported from the fuel transporting pipe 31 to the hopper 32 by a transport air A_0, is temporarily stored in the hopper 32, and is sent to the fuel supplying pipe 11 at a constant velocity by the screw feeder 34.

[0047] The biomass powder F supplied from the fuel supply pipe 11 located at the upper portion of the burner tube 12 falls toward the fuel discharge port 13 while swirling in the burner tube 12 by the primary air A_1 from the primary air supply pipe 14, and is discharged downward from the fuel discharge port 13. By combining the method of dropping the biomass powder F and the method of swirling the biomass powder F (forming the solid-gas mixed flow M), the concentration of the biomass powder F in the vicinity of the outer edge of the fuel discharge port 13 can be increased.

[0048] The powder burner device 10 may comprise a primary air control means 14a for controlling the primary air feed rate A_1 and the temperature T_1. The primary air control means 14a may include a control valve.

[0049] The heat insulating wall 17 has a conical inner wall 17a. The conical inner wall 17a is located below the burner tube 12. The conical inner wall 17a has a conical shape, the inner diameter of which increases as it goes downward. The conical shape is, for example, a frustoconical shape. Other shapes, such as a truncated polygonal pyramid shape, may be used. The increase of the cross-sectional area may be linear, curved, or stepped. The cone-shaped spreading angle (spreading solid angle) has an important role for ignition and flame holding of the biomass powder. The ignition combustion zone ZZ and the primary combustion zone Z_1 of the powder burner surrounded by the conical inner wall 17a radiate heat to heat the heat insulating wall. Therefore, radiant heat can be simultaneously emitted from the heated conical heat insulating inner wall 17a to stably maintain ignition and primary combustion. The spreading angle of the conical shape affects the spread of the flame and the heat reception distribution of the radiant heat of the conical inner wall 17a. By setting the spreading angle to an appropriate value, it is possible to keep a larger area of the conical inner wall 17a at an appropriately high temperature.

[0050] The spreading angle is preferably 4.5sr or less, more preferably 4sr or less, and particularly preferably 3.5sr or less. The spreading angle is preferably 1.5sr or more, more preferably 2sr or more, and particularly preferably 2.5sr or more. The entire inner wall of the heat insulating wall 17 may be the conical inner wall 17a with the above mentioned spreading angle, or only a part of the height ranges H1 and H2 of the heat insulating wall 17 may be the conical inner wall 17a with the above mentioned spreading angle as shown in FIGS. 4(a) and 4 (b) (i.e., the heat insulating wall 17 may include the inner wall portion 17b with a spreading angle outside of the above mentioned numerical range).The spreading solid angle in the present application refers to an average solid angle. The average solid angle can be defined by a straight line connecting the lower end and the upper end of the conical inner wall 17a as shown by the broken line in FIGS. 4A and 4B (The average solid angle can be geometrically defined by the area of the upper bottom and the lower bottom, the distance from the upper bottom to the lower bottom, and the like).

[0051] The surface temperature Tw of the heat insulating wall 17a is preferably equal to or higher than 850° C, more preferably equal to or higher than 900° C, and particularly preferably equal to or higher than 950° C. The temperature Tw can be controlled by the feed rate A_1 and the temperature T_1 of the primary air. For example, when the temperature Tw is lower than the prescribed temperature, the temperature Tw can be increased by decreasing the primary air feed rate A_1 and increasing the primary air temperature T_1. If the temperature Tw needs to be lowered in order to avoid the clinker or the like, the reverse operation (increase of the primary air feed rate A_1 and decrease of the primary air temperature T_1) can be performed.

[0052] As a result, the burner device 10 which can stably hold the flame even when a coarsely pulverized and/or high-moisture biomass powder can be used as a fuel is realized. In the powder burner device 10 of the applicant's company, it has been confirmed that by setting the cone spreading angle to πsr (π steradian), it is possible to keep a wide portion of the conical inner wall 17a at a suitably high temperature (for example, 900° C or more). As a result, enough radiant heat can be supplied to a wide area in the vicinity of the ignition zone ZZ and the combustion zone Z_1, and the ignition and flame holding properties of the biomass powder are remarkably improved. Specifically, in the powder burner device 10, biomass powder having a particle size distribution as shown in FIG. 5 (biomass powder coarsely pulverized to 30mm or less and containing 10% by weight of biomass powder having a particle size of 0.5mm or less; It is more preferable that the biomass powder is coarsely pulverized to 20mm or less, and more preferably coarsely pulverized to 10mm or less.) can stably be ignited with holding flame stably. Since a coarsely pulverized biomass powders can be used, the pulverizing cost can be greatly reduced. In the burner device 10, it is also possible to use a biomass powder having a high water content of up to about 30%.

[0053] A flame holding plate 13a is preferably disposed at the fuel discharge port 13. The flame holding plate 13a is preferably disposed in the vicinity of the outer edge of the fuel discharge port 13. The flame holding plate 13a has, for example, an annular shape concentric with the fuel discharge port 13.

[0054] The fuel discharge port 13 and the flame holding plate 13a may be disposed at the same height as the upper end of the conical inner wall 17a as shown in FIG. 2, or may be disposed above or below the upper end of the conical inner wall 17a as shown in FIGS. 4(a) to 4 (c). The flame holding plate 13a may be disposed at the same height as the fuel discharge port 13, but may be disposed at different heights as shown in FIGS. 4(d) and 4(e). However, it is not preferable to arrange the burner tube 12 below the fuel discharge port 13 (FIG. 4(e)), because the burner tube 12 is required to have a high heat resistance.

[0055] An ignition torch 15 for igniting the ignition zone ZZ may be disposed in the vicinity of the fuel discharge port 13. The biomass powder F discharged from the fuel discharge port 13 is ignited by the ignition torch 15 and burned in the ignition zone ZZ and the primary combustion zone Z_1. Therefore, the burner device 10 can be used as a burner from which a flame is discharged downward from the fuel discharge port 13. The ignition torch 15 is necessary only at the time of ignition, and does not need to be used at the time of steady operation in which ignition and flame holding are stable. Since high-quality and expensive fuels such as methane gas, propane gas, and kerosene are generally used for the ignition torch, it is preferable to use the ignition torch 15 only at the time of start-up in the combustion apparatus 40 for which low-cost operation is a major target. (The ignition torch is a compact burner independent from the main combustion system, which is an ignition source for stably maintain main combustion.)

[0056] The combustion furnace 20 has a secondary combustion zone Z_2 and a tertiary combustion zone Z_3. The secondary combustion zone Z_2 is a zone in which the biomass powder F is mainly combusted by the secondary air A_2 from the secondary air nozzles 22. The secondary combustion zone Z_2 is located downstream of the primary combustion zone Z_1. The tertiary combustion zone Z_3 is a zone intended to completely combust unburned residues with a tertiary air A_3 from the tertiary air nozzles 23. The tertiary combustion zone Z_3 is located at the furnace bottom portion downstream of the secondary combustion zone Z_2. The combustion exhaust gas G after combustion is discharged from the combustion furnace outlet 24.

[0057] In an industrial combustion apparatus, it is required to control the combustion amount and the temperature Tg of the combustion exhaust gas G in a short time (in minutes). In the combustion apparatus 40 of the present embodiment, since the combustion amount can be controlled by the supply amount of the biomass powder F and the residence time of the combustion gas in the combustion furnace 20 is several seconds, an instantaneous response is possible. The temperature Tg of the combustion gas at the furnace outlet 24 is determined by the value V calculated by the formula, V=Mf/Va, in which;

- Mf: supply amount of powder fuel (kg/h),
- Ma: total amount of supply air ($A_0+A_1+A_2+A_3$) (kg/h).

Since the A_0 and the A_1 are determined for mainly stabilizing the ignition and flame holding in the ignition zone ZZ, the temperature Tg of the combustion gas is preferably controlled by A_2 and A_3.

[0058] Since the biomass powder may be a flame retardant powder such as a powder having a particle size of 10mm class, a powder having a high moisture content of 30% class, or a powder having a high ash content of 20% class, the biomass powder may generate unburned components at the primary and secondary burning zones Z_1 and Z_2. Therefore, in order to completely combust the unburned components at the bottom of the furnace, the combustion apparatus 40 of the present invention performs tertiary combustion in the tertiary combustion zone Z_3 by the tertiary air A_3 shown in FIGS. 1 and 5. The remaining ash H is discharged into the ash basin 26 by an ash pusher 25 operated by a drive motor 27, depending on the deposition situation of the remaining ash H.

[0059] It is preferable to cool the furnace bottom surface of the combustion furnace 20 by cooling means such as a coolant supply pipe 28. When the combustion ash of the biomass powder F has a low melting point, it is considered that a clinker is generated by melting of the ash, but in the case of the low melting point ash, by controlling the rate of the air-supply quantity A_1, A_2 and A_3, a high-temperature atmosphere having an ash melting point or higher can be created to prevent the combustion ash from solidifying and accumulating on the walls of the furnace. The combustion ash descends to the furnace bottom in a molten or softened state and solidifies or coagulates at the cooled furnace bottom surface. An incinerator ash, clinker, etc. deposited on the bottom of the furnace are discharged out of the system in a timely manner by an ash removal device (such as pusher device) 25.

Embodiment

[0060] A demonstration experiment apparatus having the same configuration as the combustion apparatus 40 of FIG. 1 with a combustion amount of 70kg/h was manufactured, and a combustion experiment was carried out. The dimensions of the combustion apparatus 20 are as follows:

height: 2.3m
cross-sectional upper diameter of the furnace: 0.56 m
lower diameter of the furnace: 0.75m
volume: 0.81m^3
furnace loading: 80,000kcal/m^{3}h

This is 9.5 times the furnace loading (40,000kcal/m^{3}h) in the stoker-type combustion apparatus (conventional updraft stoker-type combustion apparatus) described in the Prior Art section. Considering that a wind box is required in the stoker system, it has been shown that the combustion apparatus 40 of the present embodiment can be reduced in volume to approximately one-tenth of the stoker system.

[0061] The biomass powder used for the experiment in the demonstration experiment apparatus is three types: wood flour (wood power), rice hulls, and weeds. These raw material powders were coarsely pulverized by a hammer mill in which an appropriate mill outlet screen was set, and the biomass powders F1 to F3 to be tested having the particle size distribution shown in FIG. 6 were prepared. As shown in FIG. 6, the test biomass powders F1 to F3 have a maximum particle diameter of 8 to 10mm and contain 10% or more of biomass powder having a particle diameter of 0.5mm or less.

[0062] The ignition and flame holding stability test results in the above demonstration test apparatus are shown in FIGS. 7 to 9. (In FIGS. 7 to 9, NT means normal temperature, SI means stable ignition, US means unstable ignition and NI means not ignitable.) The moisture content of the biomass powders F1 to F3 to be tested was about 10%, 20% and 30%. The moisture content was adjusted by intentional humidification. In each of the tests, the ignition stability was tested by changing the primary air temperature T_1 and the primary air supply amount A_1 while paying attention to the temperature Tw of the heat insulating walls serving as an ignition source. In FIGS. 7 to 9, the horizontal axis represents the primary-air temperature T_1 and the vertical axis represents the insulating wall temperature Tw. The primary air supply amount A_1 is numerically shown in the drawings as the air ratio λ_1 with respect to the supply amount of the powders F1 to F3 (the weight ratio of A_1 to the stoichiometric air amount). The insulating wall temperature Tw was controlled by the primary air temperature T_1 and the air ratio λ_1.

[0063] FIG. 7 shows test results when cedar flour (cedar powder) F1 is used. As shown in FIG. 7, at a moisture content (MC) of about 10%, even when the primary air temperature T_1 is 100° C, the insulating wall temperature Tw is 900° C, and stable ignition is achieved. Since the Tw exceeds 1000° C when the primary air temperature T_1 becomes high, the Tw is lowered by increasing λ_1 to cope with the clinker. Though Tw was not increased with the powder containing 30% moisture content, Tw was able to be increased to 900° C by throttling (reducing) λ_1 with keeping the primary air-temperature T_1 at 300° C, and stable ignition was achieved. From these results, it was found that the effect of the ignition energy by the radiant heat in the vicinity of the fuel discharge port 13 was large, and it was shown that stable ignition was possible by setting the temperature Tw of the heat insulating wall 17 to 900° C or more even in the case coarsely pulverized and highly water-containing biomass powder defined in the present application is used.

[0064] In the combustion test of the cedar powder F1 having a moisture content of 20%, the following results are obtained.

(1) It was confirmed that by adjusting the supply amount of the cedar powder F1, the combustion amount could be adjusted in the range of 60 to 100% without any problem.
(2) By adjusting the secondary air supply amount A_2

and the tertiary air supply amount A_3, it was confirmed that the temperature Tg of the combustion exhaust gas G can be adjusted in the range of 950 to 1150° C without any problems.

(3) Though unburned content was also generated for relatively large particles even with cedar powder, the third combustion zone Z_3 at the bottom of the furnace played its role and clean combustion was achieved.

(4) Clean combustion with carbon monoxide CO content of 50ppm or less was achieved at all time. From the experience thus far, it can be judged that the dioxin generation is also lower than the exhaust gas regulation value.

[0065] FIG. 8 is a test result when the rice hull powder F2 is used. The ignition stability was slightly inferior to that of cedar flour, but stable ignition was obtained even at a moisture content of 30% at an insulating wall temperature Tw of 900° C. The rice hulls contained about 15% ash, but most of the ash was deposited on the bottom of the furnace, and it was confirmed that the ash could be discharged out of the system without any problem.

[0066] FIG. 9 is a test result when weed powder F3 is used. Similar to FIGS. 7 and 8, the test was conducted with three types of moisture contents of 10%, 20% and 30%, and for all of them, stable ignition and flame holding were achieved at a temperature Tw of 900° C or higher. There was clinker generation which was not observed in cedar powder F1 and rice hull powder F2, but it was possible to suppress clinker generation by lowering the primary air temperature T_1 and increasing the primary air feed rate A_1 to control the temperature of the insulating walls to 900 to 1030° C.

[0067] The experimental results obtained using the above demonstration test apparatus are summarized as follows.

(1) The combustion apparatus of the present application has a volume of about 1/10 of that of a conventional stoker type combustion apparatus, so that miniaturization of the apparatus can be achieved.

(2) Most biomass such as grass, wood, and food residue can be used as biomass powder in the combustion apparatus of the present invention.

(3) In the combustion apparatus of the present application, biomass powder having a maximum particle diameter of 10mm or less and containing 10% by weight or more biomass powder having a particle diameter of 0.5mm or less can be used as a fuel. Therefore, the processing cost of the biomass powder can be drastically reduced. Furthermore, the moisture content can be tolerated up to 30%, so that further cost reduction is possible.

(4) The combustion amount and the combustion exhaust gas temperature at the combustion furnace outlet, which are required for an industrial combustion apparatus, can be controlled in a short time (in minutes).

(5) The combustion apparatus of the present application is capable of clearing the exhaust gas regulation value for the combustion exhaust gas.

(6) The combustion apparatus of the present application does not cause a clinker adherence trouble even in the case of a low melting point ash fuel because the furnace bottom has a cooling structure.

[0068] The powder burner device and the combustion apparatus of the present application attains stable ignition and flame holding using biomass containing 10% by weight of biomass powder having a diameter of 0.5mm or less as a fuel, and a wide variety of biomass including woods such as general wood, wood waste, construction waste, bark and pruned branches and plants such as rice straw, wheat straw and rice hulls, coffee residue and food residue can be used as an industrial fuel without incurring a great cost for pulverization. In addition, the volume of the combustion apparatus can be reduced to about 1/10 of that of the grate combustion device, the combustion gas amount and the combustion temperature can be controlled in a short time (in minutes), the combustion exhaust gas has extremely small unburned content, and the harmful gas content such as dioxin can be kept below the exhaust gas regulation standard. Since the combustion apparatus can be stably operated and controlled in the same level as the petroleum or gas fuel apparatus, it is possible to replace the existing fossil fuel combustion apparatus. For example, it can be used as a newly installing or replacing combustion apparatus for a renewable energy company, a lumber mill, a food factory, a waste disposal company, a waste generation business site, or the like.

BRIEF DESCRIPTION OF THE DRAWINGS

[0069]

10: burner device
11: fuel supply pipe
12: burner tube
13: fuel outlet
13a: flame holding plate
14: primary air supply pipe
14a: primary air control means
15: ignition torch
16: thermocouple
17: heat insulating wall
17a: conical inner wall
20: combustion furnace
21: furnace wall
22: secondary air nozzle
23: tertiary air nozzle
24: combustion furnace outlet
25: ash removal device
26: ash reservoir

27: drive motor
28: coolant supply pipe
30: fuel supply device
31: fuel transport pipe
32: hopper
33: motor
34: screw feeder
40: combustion device
A_0: transport air
A_1: primary air or primary air volume
A_2: secondary air or secondary air volume
A_3: tertiary air or tertiary air volume
C: coolant
F: powder fuel or powder fuel supply amount
G: combustion gas
T_1: primary air temperature
T_g: combustion gas outlet temperature
T_w: insulation wall temperature around the burner outlet
H: deposited ash
M: solid-air mixed flow of powder fuel and primary air
Z_1: primary combustion zone
Z_2: secondary combustion zone
Z_3: tertiary combustion zone
ZZ: ignition and combustion zone

Claims

1. A powder burner device comprising:

a burner tube,
a fuel supply device that supplies biomass powder to the burner tube, and
a primary air supply pipe connected to the side wall of the burner tube, wherein;
a biomass powder supplied from the fuel supply device falls within the burner tube while being swirled by the primary air supplied from the primary air supply pipe and is discharged from a fuel discharge port at a lower end of the burner tube, **characterized in that**;
a heat insulating wall having a conical inner wall is provided below the fuel discharge port.

2. A burner device according to claim 1, wherein a spreading solid angle of the conical inner wall is 3.5 steradian or less.

3. A burner device according to claim 1 or 2, wherein the biomass powder has a maximum particle size of 30mm or less and contains 10% by weight or more of a biomass powder having a particle size of 0.5mm or less.

4. A burner device according to any one of claims 1 to 3, further comprising a primary air control means for controlling the temperature and supply amount of the primary air so that the temperature of the conical inner wall is kept at 900°C or higher.

5. A combustion furnace comprising:

a burner device according to any one of claims 1 to 4 and
a combustion furnace directly connected to a lower part of the burner device.

6. A combustion furnace of claim 5, wherein said combustion furnace comprises:

a primary combustion zone downstream of the fuel supply port,
a secondary combustion zone downstream of the primary combustion zone for main combustion by a secondary air blown into the secondary combustion zone,
a tertiary combustion zone downstream of the secondary combustion zone for combusting an unburned content by a tertiary air blown into the tertiary combustion zone, and
a secondary air control means and a tertiary air control means for controlling the supply amounts of the secondary air and the tertiary air.

7. A combustion furnace according to claim 5 or 6, further comprising an ash removal device for removing a combustion ash accumulated on a bottom surface of the furnace to outside of the system.

Fig. 1

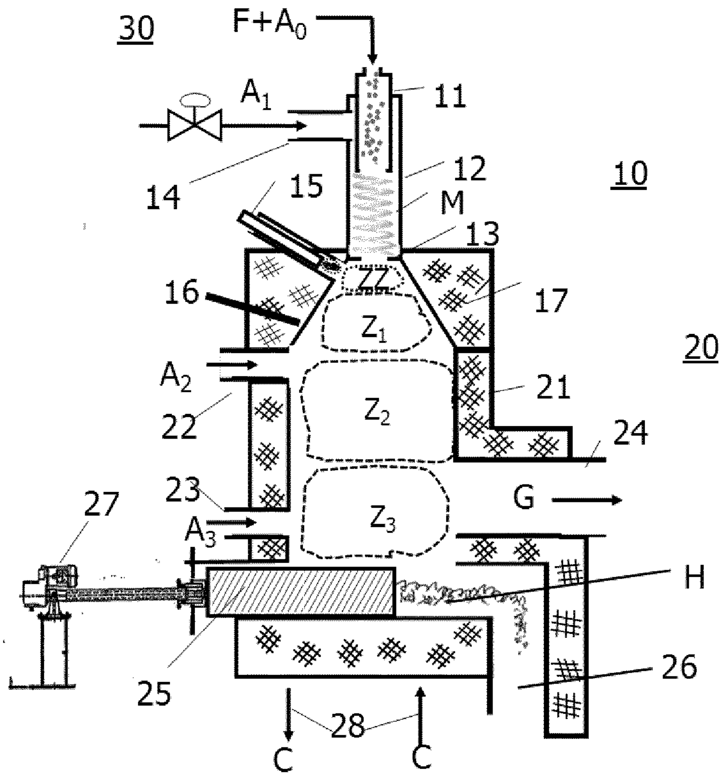

30
F+A_0
A_1
11
12
10
14
15
M
13
16
17
ZZ
Z_1
40
20
A_2
21
22
Z_2
24
23
27
G
A_3
Z_3
H
25
26
28
C
C

Fig. 2

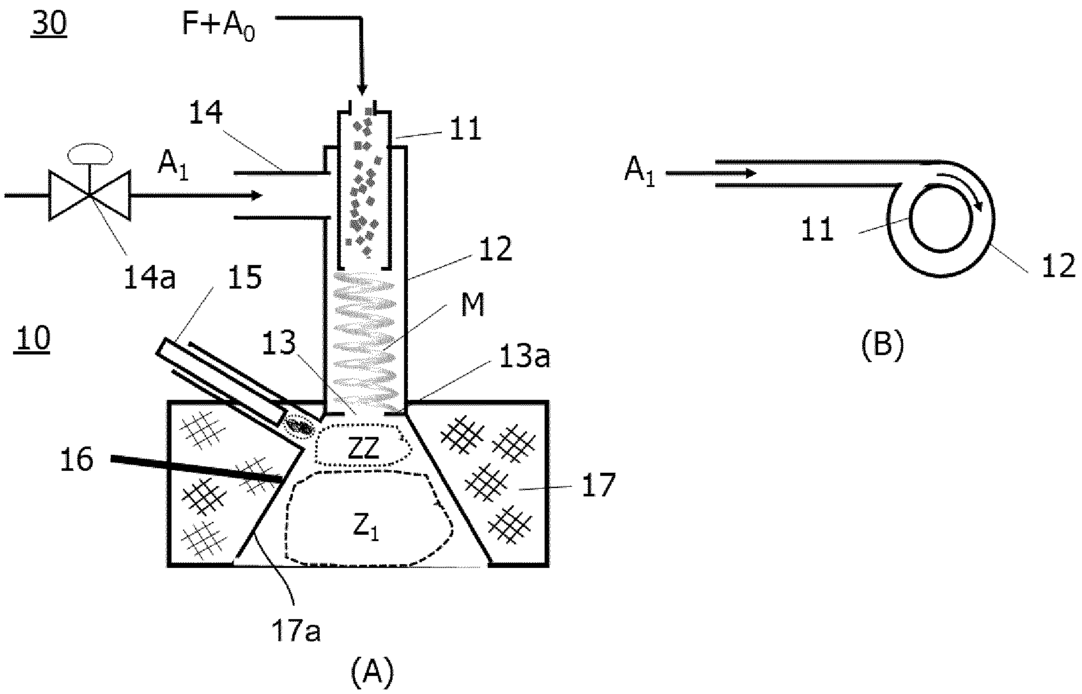

30
F+A_0
14
11
A_1
A_1
11
12
14a
15
12
M
10
13
13a
(B)
ZZ
16
17
Z_1
17a
(A)

Fig. 3

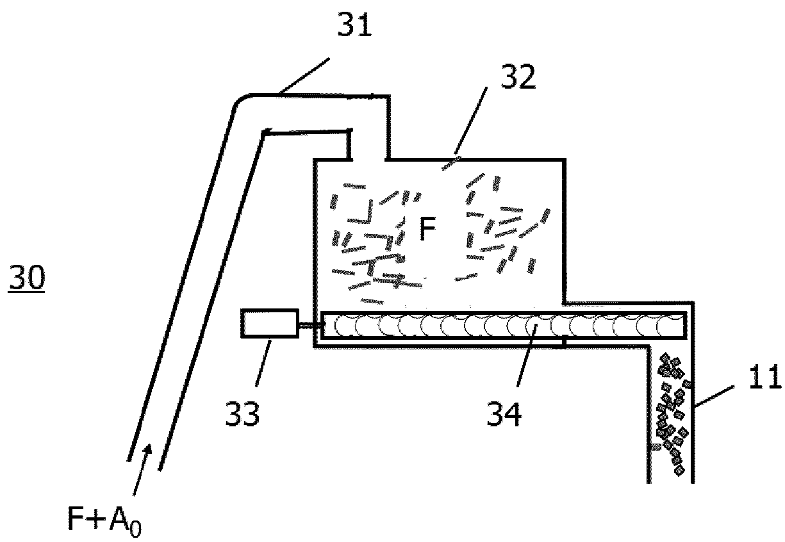
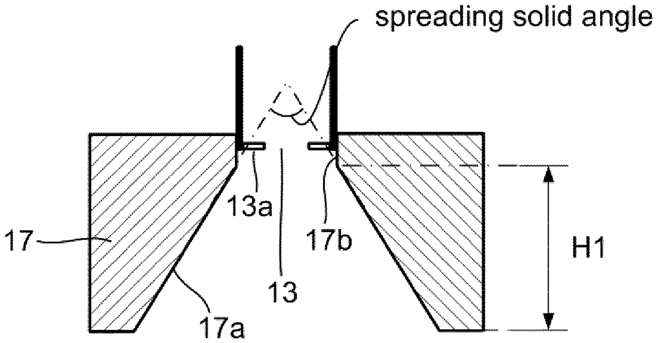
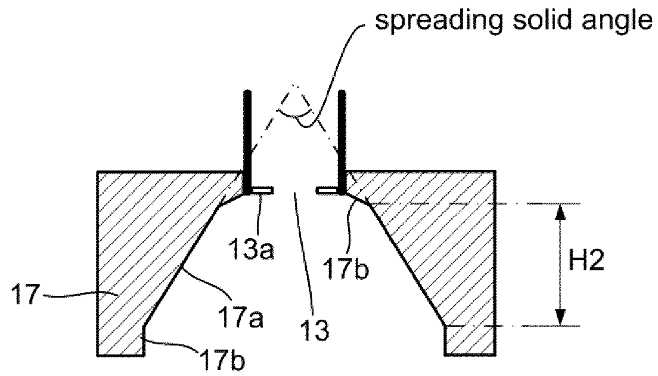


Fig. 4

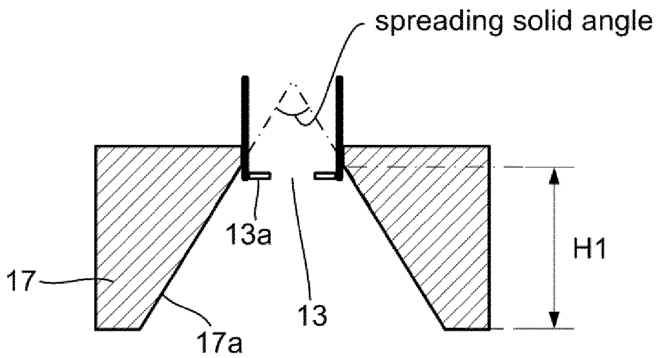
(a)


spreading solid angle
13a
17
17b
H1
13
17a

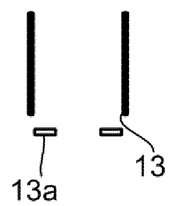
(b)


spreading solid angle
13a
17b
H2
17
17a
13
17b

(c)


spreading solid angle
13a
H1
17
13
17a

(d)


13
13a

(e)

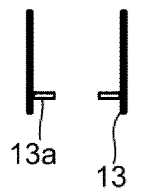

13a
13

Fig. 5

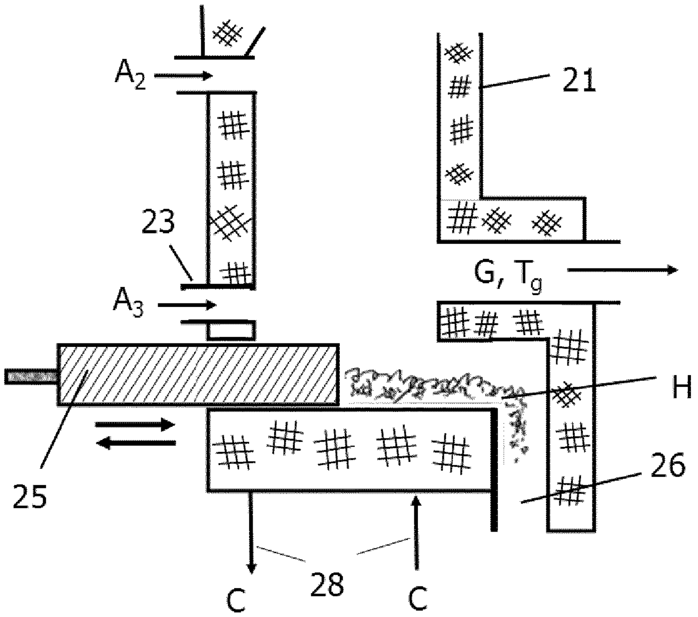

A2
21
23
A3
G, Tg
H
26
25
C
28
C

Fig. 6

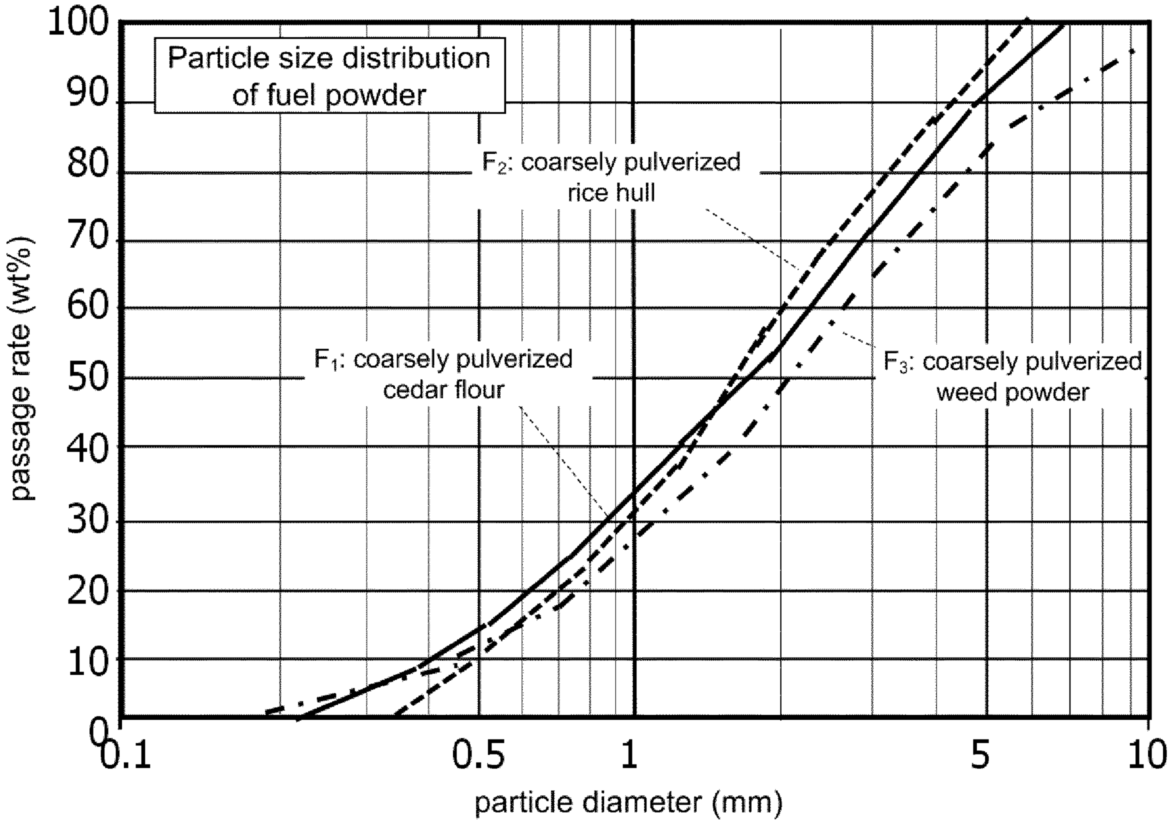

Particle size distribution of fuel powder
F2: coarsely pulverized rice hull
F1: coarsely pulverized cedar flour
F3: coarsely pulverized weed powder
passage rate (wt%)
100
90
80
70
60
50
40
30
20
10
0
0.1
0.5
1
5
10
particle diameter (mm)

Fig. 7

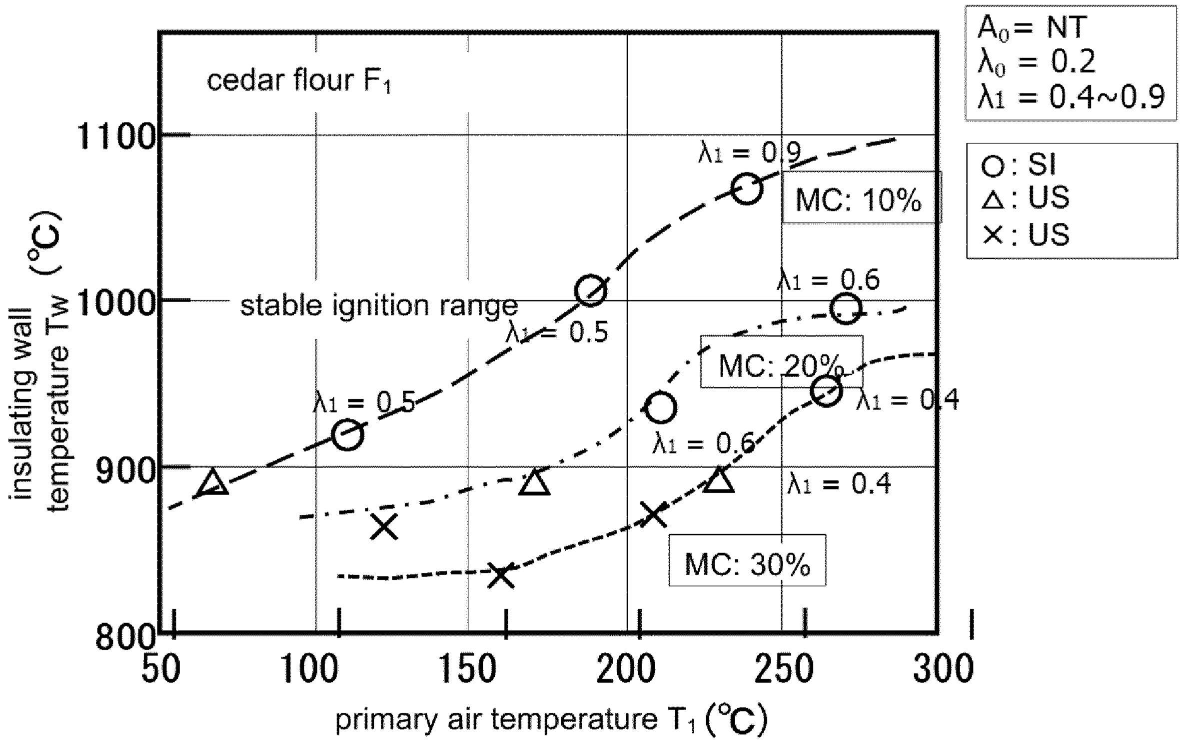

cedar flour F_1
stable ignition range
λ_1 = 0.9
λ_1 = 0.5
λ_1 = 0.5
λ_1 = 0.6
λ_1 = 0.6
λ_1 = 0.4
λ_1 = 0.4
MC: 10%
MC: 20%
MC: 30%
1100
1000
900
800
50
100
150
200
250
300
insulating wall temperature Tw (℃)
primary air temperature T_1 (℃)
A_0= NT
λ_0 = 0.2
λ_1 = 0.4~0.9
O: SI
Δ: US
×: US

Fig. 8

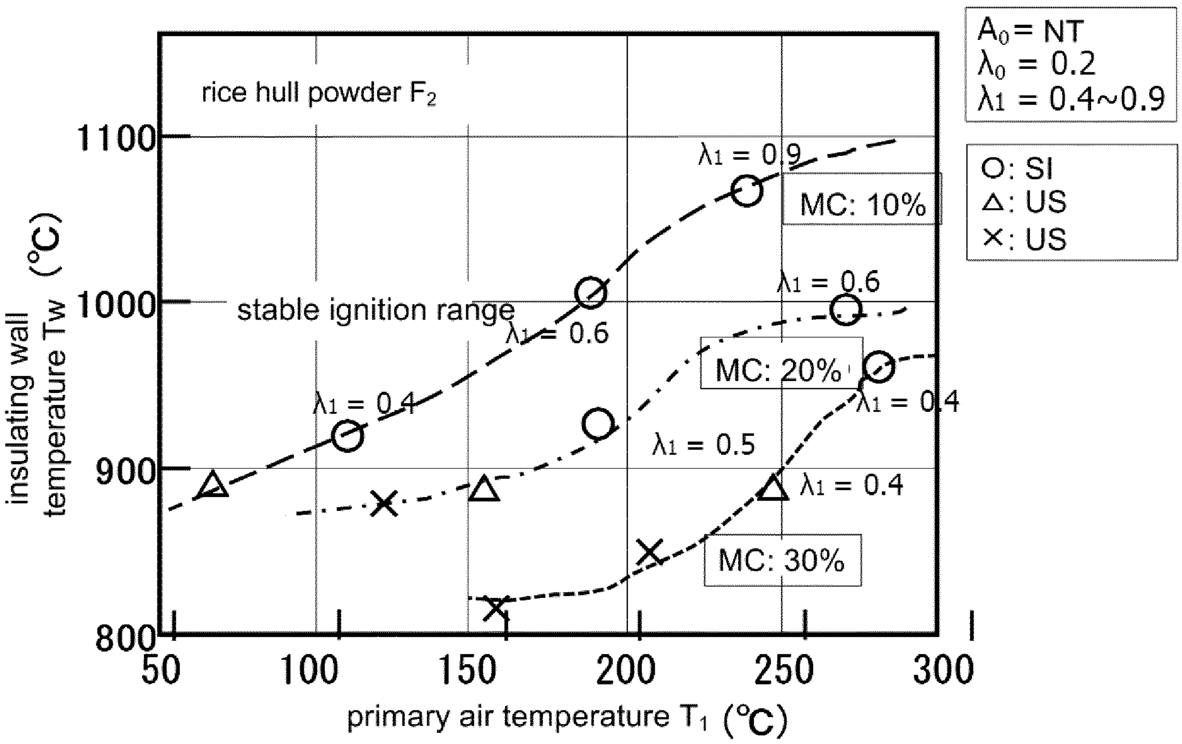
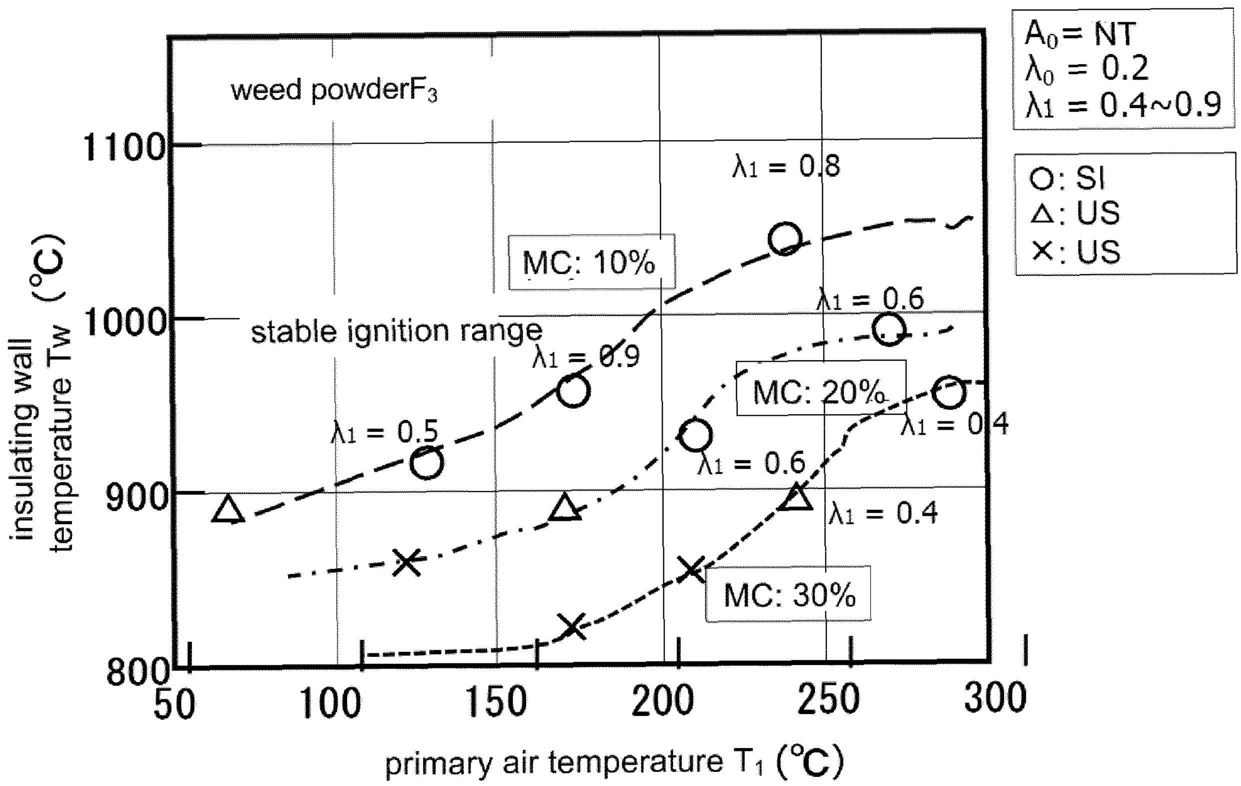

rice hull powder F_2
stable ignition range
λ_1 = 0.9
λ_1 = 0.6
λ_1 = 0.4
λ_1 = 0.6
λ_1 = 0.5
λ_1 = 0.4
λ_1 = 0.4
MC: 10%
MC: 20%
MC: 30%
1100
1000
900
800
50
100
150
200
250
300
insulating wall temperature Tw (℃)
primary air temperature T_1 (℃)
A_0= NT
λ_0 = 0.2
λ_1 = 0.4~0.9
O: SI
Δ: US
×: US

Fig. 9


weed powderF3
A0= NT
λ0 = 0.2
λ1 = 0.4~0.9
O: SI
Δ: US
×: US
λ1 = 0.8
MC: 10%
λ1 = 0.6
stable ignition range
λ1 = 0.9
MC: 20%
λ1 = 0.4
λ1 = 0.5
λ1 = 0.6
λ1 = 0.4
MC: 30%
1100
1000
900
800
50
100
150
200
250
300
insulating wall temperature Tw (°C)
primary air temperature T1 (°C)

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2019/016494

A. CLASSIFICATION OF SUBJECT MATTER
Int. Cl. F23D1/02(2006.01)i

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
Int. Cl. F23D1/02

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Published examined utility model applications of Japan	1922-1996
Published unexamined utility model applications of Japan	1971-2019
Registered utility model specifications of Japan	1996-2019
Published registered utility model applications of Japan	1994-2019

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	JP 2014-206346 A (BIOMASS ENERGY KK) 30 October 2014, paragraphs [0041]-[0056], [0061], [0062], fig. 3, 5 (Family: none)	1-7
Y	US 4206712 A (VATSKY, Joel) 10 June 1980, column 3, lines 28-35, fig. 1 & US 4249470 A & US 4270895 A	1-7
Y	JP 47-31895 A (PECHINEY UGINE KUHLMANN) 13 November 1972, page 4, lower left column, lines 1-4, fig. 1 (Family: none)	1-7

☒ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier application or patent but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
30.05.2019	11.06.2019

Name and mailing address of the ISA/	Authorized officer
Japan Patent Office 3-4-3, Kasumigaseki, Chiyoda-ku, Tokyo 100-8915, Japan	Telephone No.

Form PCT/ISA/210 (second sheet) (January 2015)

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2019/016494

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	JP 48-25226 A (RESSORTS DU NORD S.A.) 02 April 1973, amended specification, column 6, lines 10-19, fig. 1 & US 3801080 A, column 3, lines 3-13, fig. 1 & US 3868212 A & GB 1398327 A & DE 2236765 A1 & BE 786738 A & CH 561879 A5 & CH 575107 A5 & NL 7210588 A & AT 319619 B & SE 7609169 A & SE 419894 B & ES 405434 A1 & CA 966058 A & IL 39980 A & IT 964871 B	1-7
Y	Microfilm of the specification and drawings annexed to the request of Japanese Utility Model Application No. 151767/1981 (Laid-open No. 59812/1983) (NIHON HODOU KK) 22 April 1983, description, page 2, line 13 to page 3, line 9, fig. 1, 3 (Family: none)	1-7
Y	JP 11-132425 A (SANKI ENGINEERING CO., LTD.) 21 May 1999, paragraphs [0029]-[0034], fig. 1 (Family: none)	6-7
Y	Microfilm of the specification and drawings annexed to the request of Japanese Utility Model Application No. 077776/1979 (Laid-open No. 180129/1980) (DAIKI INDUSTRIES CO., LTD.) 24 December 1980, description, page 3, lines 5-13, fig. 1 (Family: none)	7

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REFERENCES CITED IN THE DESCRIPTION

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