

DESCRIPTION

Title of Invention

FLUID MEDIUM REGENERATION DEVICE, COMBUSTION SYSTEM AND
COMBUSTION METHOD OF FLUIDIZED BED COMBUSTION FURNACE

Technical Field

[0001]

The present invention relates to a fluid medium regeneration device for a fluidized bed that regenerates a fluid medium forming a fluidized bed of a fluidized bed combustion furnace, a combustion system, and a combustion method of a fluidized bed combustion furnace.

Background Art

[0002]

In recent years, in order to ensure fuel, there has been an increasing demand for power generation using construction waste wood-based materials, biomass fuels other than wood-based materials, and waste fuels such as waste tires and waste plastics. Examples of such a power generation mechanism include a technique using a circulating fluidized bed boiler (hereinafter, may be referred to as a "CFB boiler") including a combustion furnace (for example, a fluidized bed combustion furnace)

that burns a combustion target and generates saturated vapor, and a superheater that is connected to a combustion furnace, uses the combustion gas generated in the combustion furnace to superheat the saturated vapor generated in the combustion furnace, and uses the saturated vapor for power generation.

[0003]

On the other hand, it is expected that, in the future, due to the depletion of petroleum resources and the biomass fuel itself, there will be many situations in which low-grade biomass fuels such as rice hulls and empty fruit bunches (EFB) are used. However, low-grade biomass fuels and waste fuels contain a large amount of impurities such as alkaline components such as Na and K. When such a low-grade fuel containing impurities such as an alkaline component is used, a compound having a low melting point (hereinafter, may be appropriately referred to as a "low melting point compound") may be produced, and the low melting point compound may cause poor flow of the fluidized bed. Therefore, it is urgent and indispensable to expand the fuel application range of the biomass fuel to the CFB boiler and suppress the poor flow of the boiler.

[0004]

For example, the following techniques have been developed as techniques for low-grade fuels containing

impurities such as alkaline components (for example, refer to PTL 1 and PTL 2 below).

Citation List

Patent Literature

[0005]

[PTL 1] Japanese Unexamined Patent Publication No.
2005-226930

[PTL 2] Japanese Unexamined Patent Publication No.
2011-106701

Summary of Invention

Technical Problem

[0006]

The technique described in PTL 1 sets the air ratio in the fluidized bed to a specific range with respect to the generation of the low melting point compound in the combustion of the highly alkaline-containing biomass fuel, sets the ratio of the exhaust gas recirculation flow rate with respect to the total air flow rate to a specific range by recirculating the exhaust gas, and controls the fluidized bed temperature to 600 to 750°C while ensuring the ratio of the superficial velocity in the fluidized bed with respect to the fluidization start speed to be 2 to 6 such that the low melting point compound suppresses

agglomeration of a fluid medium (for example, bottom ash) to prevent poor flow from occurring, and enable smooth and stable operation. However, it is not easy to constantly control the temperature of the fluidized bed to 600 to 750°C. In addition, since the shape of the fluid medium still tends to be large even when the present technique is used, a considerable amount of supply of a new fluid medium such as sand is required. Therefore, there is still room for improvement in terms of cost from the viewpoint of the fluid medium.

[0007]

The technique of PTL 2 includes a cooling water tank that separates deposits from a fluid medium by charging a fluid medium such as bottom ash extracted from the fluidized bed of a combustion furnace into water and cooling the fluid medium. Although it is possible to efficiently separate the deposits from the fluid medium by this technique, there is still room for improvement from the viewpoint of efficiently suppressing poor flow of the highly alkaline-containing biomass fuel.

[0008]

An object of the present invention is to provide a fluid medium regeneration device, a combustion system, and a combustion method of a fluidized bed combustion furnace capable of efficiently separating a coating layer from a

fluid medium in order to solve the above-described problems.

Solution to Problem

[0009]

That is, the present invention is as shown below.

[0010]

<1> There is provided a fluid medium regeneration device for a fluidized bed, including: a cooling unit that is supplied with at least, a fluid medium recovered from the fluidized bed of a fluidized bed combustion furnace is supplied, cools the fluid medium by being brought into contact with a liquid medium having a boiling point of - 20°C or lower under 1 atmospheric pressure, and separates a coating layer from the fluid medium.

<2> The fluid medium regeneration device for a fluidized bed according to <1>, in which the liquid medium is at least one of liquid air, liquid nitrogen, and liquid oxygen.

<3> The fluid medium regeneration device for a fluidized bed according to <1> or <2>, further including: sorting means that sorts the fluid medium exhausted from the cooling unit, and the coating layer.

<4> The fluid medium regeneration device for a fluidized bed according to any one of <1> to <3>, in which

a temperature of the fluid medium recovered from the fluidized bed of the fluidized bed combustion furnace is equal to or lower than a melting point of the coating layer.

<5> The fluid medium regeneration device for a fluidized bed according to any one of <1> to <4>, in which the cooling unit includes an intermediate cooling unit that further cools the fluid medium, and brings the fluid medium cooled by the intermediate cooling unit into contact with the liquid medium.

<6> The fluid medium regeneration device for a fluidized bed according to any one of <1> to <5>, in which a return unit that recovers the fluid medium from which the coating layer has been separated, and returns the fluid medium having a particle size adjusted to 50 to 1,000 μm to the fluidized bed is further provided.

<7> A combustion system including: a fluidized bed combustion furnace; and the fluid medium regeneration device for a fluidized bed according to any one of <1> to <6>.

<8> A combustion method of a fluidized bed combustion furnace using an alkaline-containing fuel, the combustion method including: recovering the fluid medium from the fluidized bed of the fluidized bed combustion furnace, cooling the fluid medium recovered from the fluidized bed

by being brought into contact with a liquid medium having a boiling point of -20°C or lower under 1 atmospheric pressure, and separating a coating layer from the fluid medium.

<9> The combustion method of a fluidized bed combustion furnace according to <8>, in which the liquid medium is at least one of liquid air and liquid nitrogen.

<10> The combustion method of a fluidized bed combustion furnace according to <8> or <9>, in which the fluid medium and the coating layer are sorted.

<11> The combustion method of a fluidized bed combustion furnace according to any one of <8> to <10>, in which a temperature of the fluid medium recovered from the fluidized bed of the fluidized bed combustion furnace is equal to or lower than a melting point of the coating layer.

<12> The combustion method of a fluidized bed combustion furnace according to any one of <8> to <11>, in which the fluid medium is cooled by an intermediate cooling unit and then brought into contact with the liquid medium.

<13> The combustion method of a fluidized bed combustion furnace according to any one of <8> to <12>, in which the fluid medium from which the coating layer has been separated is recovered, and the fluid medium having a

particle size adjusted to 50 to 1,000 μm is returned to the fluidized bed.

Advantageous Effects of Invention

[0011]

According to the present invention, it is possible to provide a fluid medium regeneration device, a combustion system, and a combustion method of a fluidized bed combustion furnace capable of efficiently separating a coating layer from a fluid medium.

Brief Description of Drawings

[0012]

Fig. 1 is a schematic view showing a combustion system including a fluid medium regeneration device for a fluidized bed according to a first embodiment of the present invention.

Figs. 2A and 2B are schematic views for describing a mechanism for forming agglomerates, Fig. 2A is a schematic view showing a coating induction mechanism by agglomerates, and Fig. 2B is a schematic view showing an agglomerate melting induction mechanism.

Fig. 3 is a K_2O - SiO_2 state diagram.

Fig. 4 is a schematic view showing a combustion system including a fluid medium regeneration device for a

fluidized bed according to a second embodiment of the present invention.

Fig. 5 is a flow chart for describing a combustion method applicable to the combustion system and the fluid medium regeneration device according to the present embodiment.

Fig. 6 is a schematic view showing a combustion system including a fluid medium regeneration device for a fluidized bed according to another aspect of the present invention.

Description of Embodiments

[0013]

Hereinafter, embodiments for carrying out the present invention (hereinafter, simply referred to as "the present embodiment") will be described in detail with reference to the drawings. However, the following embodiments are examples for describing the present invention, and the present invention is not intended to be limited to the following contents. The present invention can be appropriately modified and carried out within the scope of the gist thereof. In addition, the same reference numerals will be given to the same elements, and redundant description will be omitted. In addition, unless otherwise specified, the positional relationship such as up, down,

left, and right shall be based on the positional relationship shown in the drawings. Furthermore, the dimensional ratios in the drawings are not limited to the ratios shown in the drawings.

[0014]

[First Embodiment]

A combustion system including a fluid medium regeneration device according to the first embodiment will be described with reference to Fig. 1. Fig. 1 is a schematic view showing a combustion system including a fluid medium regeneration device for a fluidized bed according to a first embodiment of the present invention.

[0015]

As shown in Fig. 1, a combustion system 1 includes a fluidized bed combustion furnace 2 to which a combustion target is supplied and burns the combustion target in the furnace, and a fluid medium regeneration device 3. The fluid medium regeneration device 3 includes a screw conveyance machine 11 serving as a cooling unit in which a fluid medium Fa recovered from a fluidized bed F of the combustion furnace 2 is supplied, the supplied fluid medium Fa cools by being brought into contact with a liquid medium LM having a boiling point of -20°C or lower under 1 atmospheric pressure, and the coating layer is separated from the fluid medium Fa. The fluid medium regeneration

device 3 in the first embodiment is for separating the coating layer from the fluid medium Fa such as sand recovered from the fluidized bed F of the combustion furnace 2 and regenerating the fluid medium Fa.

[0016]

The combustion system 1 can use an alkali-containing fuel such as rice hulls or a highly alkaline-containing biomass fuel of empty fruit bunches (EFB) as a combustion target. Hereinafter, the highly alkaline-containing biomass fuel may be simply referred to as a "biomass fuel". The combustion system 1 includes the combustion furnace 2 that burns biomass fuel and heats water in a sealed container to generate vapor. The combustion furnace 2 is an external circulation type fluidized bed combustion furnace, and is a so-called circulating fluidized bed (CFB) boiler. A fuel charging port for charging fuel is provided in an intermediate portion of the combustion furnace 2, and biomass fuel is charged from the fuel charging port. However, the combustion target used in the combustion system 1 is not limited to the biomass fuel, and any alkaline-containing fuel can be used without particular limitation.

[0017]

Further, the fluid medium Fa such as sand containing quartz particles as a main component is charged into the

combustion furnace 2, and air is supplied into the fluid medium Fa from a lower portion (bottom portion) of the furnace, and the fluid medium Fa flows to form the fluidized bed F. The formation of the fluidized bed F promotes the combustion of the biomass fuel. In addition, the combustion gas generated as a result of the combustion of the biomass fuel rises in the combustion furnace 2 with a part of the fluid medium Fa. Here, the "fluid medium" in the present specification also includes a bottom ash generated by combustion of a biomass fuel. In addition, the "bottom ash" is mainly composed of a fluid medium such as sand, and includes combustion ash produced by combustion of biomass fuel and the fluid medium Fa coated with and agglomerated by components in biomass fuel. According to the combustion system including the fluid medium regeneration device in the present embodiment, by separating a "coating layer" (including deposits) generated by the components in the biomass fuel from the fluid medium Fa (agglomerate) coated with and agglomerated by the components in the biomass fuel, the fluid medium Fa can be regenerated to be reusable. In addition, when the term "coating layer" is simply referred to below, the mere deposits generated by the components in the biomass fuel are also included.

A gas outlet 2A for exhausting the combustion gas is provided in an upper portion of the combustion furnace 2. A cyclone separator 4 that functions as a solid-gas separation device is connected to the gas outlet 2A. The combustion gas generated in the combustion furnace 2 is introduced into the cyclone separator 4 while being accompanied by solid particles. The cyclone separator 4 separates a recovered solid particles from the combustion gas by a centrifugal separation action. The recovered solid particles separated from the combustion gas are returned to the combustion furnace 2 through a return line 5. The recovered solid particles include a fluid medium such as bottom ash or sand. On the other hand, the combustion gas from which the recovered solid particles have been removed is sent to a heat recovery device 6 through an exhaust port 4A.

[0019]

The return line 5 is composed of a pipeline connected to the lower portion of the combustion furnace 2, and a loop seal 5A is provided in the middle of the return line 5. The loop seal 5A is a facility that prevents the combustion gas from flowing back into the combustion furnace 2. The fluid medium Fa fed from the cyclone separator 4 is accumulated in the loop seal 5A. Further, the fluid medium Fa in the loop seal 5A is charged into the

combustion furnace 2 from a return chute portion 5B which is the outlet of the loop seal 5A.

[0020]

The heat recovery device 6 has a boiler tube (not shown) that forms a flow path for the combustion gas and allows water as a heat medium to flow. The boiler tube is provided to cross the flow path of the combustion gas in the heat recovery device 6, and recovers the heat of the combustion gas sent from the cyclone separator 4 by heat exchange with the water in the tube. In the boiler tube, high-temperature water vapor is generated by the recovered heat, and the water vapor is sent to a power generation turbine or the like (not shown) through the boiler tube. In addition, the heat recovery device 6 sends the combustion gas after heat recovery to a bag filter 7 through an exhaust port 6A.

[0021]

The bag filter 7 is a filtering facility that removes fine particles such as fly ash that are still accompanying the combustion gas. The combustion gas filtered by the bag filter 7 is suctioned into a suction pump 8 and exhausted from a chimney 9 to the outside of the combustion system 1.

[0022]

On the other hand, in the combustion furnace 2, in the process of combustion of the biomass fuel, combustion ash

or a part of the fuel generated by the combustion is melted with the surrounding fluid medium Fa to form an agglomerate. This agglomerate may also be referred to as "agglomeration", and when the agglomerate is accumulated in the bottom portion of the combustion furnace 2, this also causes poor flow of the fluidized bed F. Therefore, the agglomerates need to be periodically extracted from the inside of the combustion furnace 2 together with the fluid medium Fa and removed. In the present embodiment, in order to remove the coating layer (deposits), the fluid medium Fa containing the agglomerated material is extracted from the exhaust port of the combustion furnace 2 and conveyed to the fluid medium regeneration device 3.

[0023]

A mechanism for forming agglomerates in the combustion furnace 2 will be described with reference to Fig. 2. Fig. 2 is a schematic view for describing the mechanism for forming agglomerates.

[0024]

First, the formation of agglomerates, which is the main cause of poor flow of the fluidized bed F, is mostly caused by a melt of the low melting point compound, that is, a melt of a substance (for example, KCl (solid)) formed due to the alkaline component in the biomass fuel adhering to the surface of the fluid medium Fa, or is caused by

forming eutectic formation on the surface of fluid medium Fa due to the components in the biomass fuel chemically reacting on the surface of the fluid medium Fa. As described above, two main mechanisms, coating induction and melting induction, are known for the formation of agglomerates.

[0025]

(Coating Induction Mechanism)

Fig. 2A shows a mechanism for forming an agglomerate X by coating induction. Fig. 2A is a schematic view showing a coating induction mechanism of an agglomerate. As shown in Fig. 2A, the formation of the agglomerate X by the coating induction is caused by a chemical reaction between vapor (for example, KCl, K₂SO₄, or the like) of an alkaline component (potassium, sodium, or the like) in the biomass fuel (N in Fig. 2A) and quartz particles (sand) which are the main components of the fluid medium Fa. In particular, KCl tends to become vapor at 700°C or higher. As a result of the chemical reaction, a eutectic coating C (for example, K₂O-SiO₂:alkali silicate phase) having an adhesive property is formed on the surface of the fluid medium Fa. After that, the fluid media Fa on which the eutectic coating C is formed repeat bonding and dispersal in the fluidized bed F. As a result, particle agglomeration is

started, and the agglomerate X that gradually hinder the flow is formed.

[0026]

The main control factors of the mechanism for forming the agglomerate X by the coating induction are the eutectic coating thickness (easiness of bonding separation), the eutectic coating composition (bonding strength), and the local temperature. In addition, as a component contained in the biomass fuel, it has been confirmed that phosphorus is also an important factor in the formation of the agglomerate X in addition to the alkaline component.

[0027]

The eutectic coating C begins to melt at approximately 700°C as shown in the K_2O-SiO_2 state diagram in Fig. 3. Therefore, in a region (a region that burns at a high temperature) (approximately 700°C to 900°C) where the temperature is high in the combustion furnace 2, the eutectic coating C is in a molten state, and the fluid media Fa are easily agglomerated with each other.

[0028]

(Melting Induction Mechanism)

Next, a mechanism for forming the agglomerate X by melting induction will be described. Fig. 2B is a schematic view showing a melting induction mechanism. The agglomerate X formed by the melting induction is caused by the adhesion

of the melts M of the low melting point compound (alkali silicate) formed by the alkaline component in the biomass fuel to the surface of the fluid media Fa. The fluid media Fa to which the melts M adhere gradually agglomerate to each other in the fluidized bed F to form the agglomerate X. The control factors of the mechanism for forming the agglomerate X by the melting induction are the local temperature and the fuel ash composition, and in the combustion ash containing a high-concentration alkaline component and chlorine, the agglomerate X tends to be formed through the melting induction mechanism.

[0029]

(Fluid Medium Regeneration Device 3)

The fluid medium regeneration device 3 that separates a coating layer such as an alkali silicate phase from the fluid medium Fa and regenerates (reuses) the coating layer will be described. As shown in Fig. 1, the fluid medium regeneration device 3 includes a supply unit 10 to which the fluid medium Fa recovered from the fluidized bed F of the combustion furnace 2 is supplied; and a screw conveyance machine 11 cools the fluid medium Fa by bringing the fluid medium Fa into contact with the liquid medium LM supplied from a supply pipe 11A while conveying the fluid medium Fa supplied from the supply unit 10. As described above, the screw conveyance machine 11 plays the role of a

cooling unit of the fluid medium Fa. Further, the fluid medium regeneration device 3 includes a sorting device 12 that sorts the fluid medium Fa exhausted from the screw conveyance machine 11 and the coating layer, and a return mechanism 13 that recovers the fluid medium from which the coating layer is separated and returns the fluid medium to the fluidized bed F of the combustion furnace 2.

[0030]

The supply unit 10 is connected to an exhaust port provided at the bottom portion of the combustion furnace 2, and is supplied with the fluid medium Fa recovered from the fluidized bed F of the combustion furnace 2. The fluid medium recovered from the combustion furnace 2 has a high temperature (for example, 700°C) and is supplied into the screw conveyance machine 11 via the supply unit 10.

[0031]

The temperature of the fluid medium Fa recovered from the fluidized bed F of the combustion furnace 2 supplied to the supply unit 10 is not particularly limited, and is, for example, preferably equal to or lower than the melting point (for example, 700°C or lower in a case where the coating layer of $\text{SiO}_2\text{-K}_2\text{O}$ is formed on the fluid medium Fa, or the like) of the coating layer (deposits) of the fluid medium Fa and equal to or higher than the room temperature (for example, 25°C).

[0032]

The position at which the fluid medium Fa is recovered from the combustion furnace 2 is not particularly limited, but from the viewpoint of efficiently recovering the high-temperature fluid medium Fa, preferably, the fluid medium Fa of the fluidized bed F deposited from the bottom portion of the combustion furnace 2 is recovered.

[0033]

The screw conveyance machine 11 is connected to the supply unit 10 connected to the exhaust port of the combustion furnace 2, and is supplied with the high-temperature fluid medium Fa extracted from the bottom portion of the combustion furnace 2. The screw conveyance machine 11 is configured such that the screw is rotated by the drive of the motor represented by "M" in the drawing, and the fluid in the device can be conveyed. In addition, the screw conveyance machine 11 is cooled in advance, and in order to cool the screw conveyance machine 11 in advance, cooling means other than the liquid medium L such as water can be used. A supply pipe 11A is connected to the screw conveyance machine 11, and is configured such that the liquid medium LM is supplied into the conveyance path of the screw conveyance machine 11 by a pump or the like (not shown). The position where the liquid medium LM of the screw conveyance machine 11 is supplied is not particularly

limited, and the supply position of the liquid medium LM can be set such that the liquid medium LM comes into contact with the fluid medium Fa at an optimum location in the screw conveyance machine 11. For example, as shown in Fig. 1, the liquid medium LM may be supplied from the downstream side of the screw conveyance machine 11, or may be configured to be supplied from the upstream side of the screw conveyance machine 11, or across the entire screw conveyance machine 11.

[0034]

In the present embodiment, the liquid medium LM is a liquid having a boiling point of -20°C or lower under 1 atmospheric pressure and is a liquid medium capable of maintaining a low temperature below 0°C . In addition, as used in the present specification, the "liquid medium" also includes a gas medium in which the liquid medium has evaporated. Examples of the liquid medium LM include liquid air (boiling point under 1 atmospheric pressure: approximately -190°C), liquid nitrogen (boiling point under 1 atmospheric pressure: approximately -196°C), liquid oxygen (boiling point under 1 atmospheric pressure: approximately -183°C), liquid hydrogen (boiling point under 1 atmospheric pressure: approximately -252.6°C), and the like. The liquid medium LM can be appropriately sorted according to, for example, fuel conditions (amount of an

alkaline component (for example, potassium) brought into the furnace) in the combustion furnace 2, but from the viewpoint of ease of handling, availability, safety, and the like, at least one of liquid air, liquid nitrogen, and liquid oxygen is preferable.

[0035]

The high-temperature cooling shrinkage difference conveyed in the screw conveyance machine 11 comes into contact with the liquid medium LM and is rapidly cooled. When the fluid medium Fa (agglomerate) with a coating layer such as the eutectic coating C such as an alkali silicate phase formed by the above-described coating induction mechanism or the melts M of the low melting point compound (alkali silicate) on the surface thereof by the melting induction mechanism comes into contact with the liquid medium LM, the fluid medium Fa and the coating layer are rapidly cooled from a high-temperature state, and the coating layer is separated from the fluid medium Fa due to a thermal expansion difference (cooling shrinkage difference) between the fluid medium Fa and the coating layer. The separation utilizes the cooling shrinkage difference due to a difference in material (that is, a difference in physical properties) between the coating layer (for example, alkali silicate or the like) and the induction medium (sand or the like).

[0036]

In addition, although not particularly limited, from the viewpoint of effectively causing separation of the fluid medium Fa and the coating layer due to the cooling shrinkage difference in the screw conveyance machine 11, the difference between the temperature of the fluid medium Fa and the temperature of the liquid medium LM is preferably 120 to 410°C.

[0037]

The fluid medium Fa and the coating layer, which have been cooled and separated in the screw conveyance machine 11, are exhausted from the exhaust port of the conveyance machine and are supplied to the sorting device 12 positioned in a subsequent stage. In this case, since the liquid medium LM volatilizes immediately after coming into contact with the fluid medium Fa, the separated fluid medium Fa and the coating layer are supplied to the sorting device 12 in a dry state.

[0038]

In the sorting device 12, a sieve is installed as sorting means in the sorting device 12, and further, a discharge pipe 12A and a supply pipe 12B are connected. The mixture of the fluid medium Fa and the coating layer supplied from the screw conveyance machine 11 to the sorting device 12 via the supply pipe 12B is sorted into

the fluid medium Fa and a combustion-unsuitable material such as the coating layer in the sorting device 12. The sorting device 12 sorts the fluid medium Fa and a material other than the fluid medium Fa (that is, the combustion-unsuitable material such as the coating layer) by a sieve using a particle size difference between the fluid medium Fa and the coating layer. The fluid medium Fa sorted by the sorting device 12 is conveyed to the return mechanism 13. In addition, the combustion-unsuitable material, such as the coating layer sorted by the sorting device 12, is exhausted from the discharge pipe 12A to the outside of the system.

[0039]

The mesh size of the sieve provided in the sorting device 12 is not particularly limited. However, since the particle size of the coating layer to be removed is several μm or less, for example, by setting the mesh size of the sieve to 50 μm or less, the fluid medium Fa and the coating layer can be sorted. As the sieve provided in the sorting device 12, for example, from the viewpoint of the particle size of the fluid medium Fa, a sieve having 270 to 325 meshes (mesh size of 45 to 53 μm) based on the mesh size based on the American Society for Testing and Materials (ASTM standard) can be used. In addition, the sieve in the

sorting device 12 may be composed of either a single stage or a multi-stage.

[0040]

The return mechanism 13 is a mechanism that recovers the fluid medium Fa from which the coating layer has been separated and returns the fluid medium Fa to the fluidized bed. In addition, the return mechanism 13 is provided with a particle size adjusting device 13A and a return line 13B that adjust the fluid of the fluid medium Fa.

[0041]

The sorted fluid medium Fa conveyed from the sorting device 12 to the return mechanism 13 is first supplied to the particle size adjusting device 13A. A sieve is installed in the particle size adjusting device 13A as particle size adjusting means, and the particle size of the fluid medium Fa is adjusted. The particle size adjusting device 13A can adjust the particle size of the fluid medium Fa to, for example, 50 to 1,000 μm from the viewpoint of further removing foreign matter from the fluid medium Fa and increasing the purity (quality) of the fluid medium Fa returned into the combustion furnace 2.

[0042]

The mesh size of the sieve provided in the particle size adjusting device 13A is not particularly limited, but in order to remove foreign matter having a size of 1,000 μm

or more, for example, the mesh size of the sieve can be set to 1,000 μm or more. As the sieve provided in the particle size adjusting device 13A, for example, from the viewpoint of the particle size of the fluid medium Fa, a sieve having 16 to 18 meshes (mesh size of 1,000 to 1180 μm) based on the mesh size based on the American Society for Testing and Materials (ASTM standard) can be used. In addition, the sieve in the particle size adjusting device 13A may be composed of either a single stage or a multi-stage.

[0043]

The return line 13B for returning to the fluidized bed F of the combustion furnace 2 is connected to the particle size adjusting device 13A. The fluid medium Fa of which the particle size has been adjusted in the particle size adjusting device 13A is exhausted to the return line 13B. In Fig. 1, the "a" mark indicated by the arrow of the return line 13B communicates with the location of the "a" mark on the side of the combustion furnace 2, and means that the fluid medium Fa recovered by the return mechanism 13 is returned from the fuel charging port of the combustion furnace 2 to the fluidized bed F.

[0044]

According to the fluid medium regeneration device 3 of the first embodiment and the combustion system 1 incorporating the fluid medium regeneration device 3

described above, by bringing the high-temperature fluid medium Fa extracted from the bottom portion of the fluidized bed F of the combustion furnace 2 into contact with the liquid medium having a boiling point of -20°C or lower under 1 atmospheric pressure, and by rapidly cooling the fluid medium Fa, peeling of the coating layer due to a shrinkage difference between the fluid medium Fa and the coating layer is caused. This is because the physical properties of the alkali silicate phase such as $\text{K}_2\text{O-SiO}_2$ and the fluid medium Fa such as sand are different, and as a result of occurrence of a shrinkage difference due to rapid cooling, separation of the fluid medium Fa and the coating layer is realized.

[0045]

As described above, according to the fluid medium regeneration device 3 and the combustion system 1 incorporating the fluid medium regeneration device 3, as compared with the conventional device utilizing the physical collision, the shrinkage difference based on the difference in the physical properties between the fluid medium Fa and the coating layer is utilized, and accordingly, the coating layer is separated from the fluid medium Fa and the fluid medium Fa is regenerated extremely efficiently, and thus the quality assurance and effective

utilization of the fluid medium Fa which is the circulation material can be achieved.

[0046]

Further, according to the fluid medium regeneration device 3, the fluid medium Fa separated from the coating layer can be recovered by the return line 13B and returned to the fluidized bed F. Therefore, it is possible to return the fluid medium Fa extracted from the fluidized bed F to the fluidized bed F and automatically replenish the fluid medium Fa, and it is possible to reduce the labor related to the replenishment of the fluid medium Fa.

[0047]

Furthermore, according to the fluid medium regeneration device 3 and the combustion system 1 in the present embodiment, the particles of the fluid medium Fa can be handled in a dry state in the present embodiment. Therefore, the conveyance in the sorting device 12 and the return mechanism 13 is smooth, the recycling of the fluid medium Fa is facilitated, and the amount of moisture brought in when the fluid medium Fa is returned to the fluidized bed F in the combustion furnace 2 can be reduced. Further, according to the fluid medium regeneration device 3 and the combustion system 1 in the present embodiment, the fluid medium Fa can be returned to the boiler without going through a drying process or the like. Therefore, in

the fluid medium regeneration device 3 and the combustion system 1 in the present embodiment, the fluid medium can be reused advantageously in terms of efficiency and cost, and can also be suitably applied to a large-sized combustion furnace 2 that uses a large amount of fluid medium Fa (such as sand).

[0048]

[Second Embodiment]

In the first embodiment, the aspect in which the high-temperature fluid medium recovered from the combustion furnace 2 is brought into contact with the liquid medium LM as it is has been described, but the aspect of the present invention is not limited to such an aspect. For example, in the first embodiment, a conveyance path of the cooling unit (for example, the screw conveyance machine 11) may be ensured to some extent, and the temperature of the fluid medium may be lowered to some extent before coming into contact with the liquid medium. An intermediate cooling unit that further cools the fluid medium may be provided in the cooling unit, and the fluid medium cooled by the intermediate cooling unit may come into contact with the liquid medium.

[0049]

Hereinafter, an aspect in which the screw conveyance machine 11 has a cooling medium flow path (intermediate

cooling unit) will be described with reference to Fig. 4. Fig. 4 is a schematic view showing a combustion system including a fluid medium regeneration device for a fluidized bed according to a second embodiment of the present invention.

[0050]

As shown in Fig. 4, the fluid medium regeneration device 22 of the combustion system 21 in the second embodiment is different from the first embodiment only in that the fluid medium Fa is cooled when the fluid medium Fa is conveyed by the screw conveyance machine 11. Hereinafter, the same reference numerals will be given to the members having the same configuration as that of the first embodiment, and the description thereof will be omitted.

[0051]

In the combustion system 21 of the second embodiment, in the fluid medium regeneration device 22, a cooling medium flow path 23 through which a cooling medium such as water flows is formed around an upstream portion of the screw conveyance machine 11. Both ends of the cooling medium flow path 23 are connected to a circulation pipeline for circulating the cooling medium, and a cooling medium tank 24 for storing the cooling medium and a pump 26 for smooth flow of the cooling medium are provided in the

middle of the pipeline. In addition, a cooler 25 for cooling the cooling medium in the cooling medium tank 24 is provided below the cooling medium tank 24.

[0052]

In the fluid medium regeneration device 22, when the high-temperature fluid medium Fa exhausted from the exhaust port of the combustion furnace 2 is conveyed in the upstream portion of the screw conveyance machine 11, the fluid medium Fa is cooled as heat is transferred to the cooling medium in the cooling medium flow path 23. The fluid medium Fa is cooled until the temperature immediately before being charged into the screw conveyance machine 11 reaches a predetermined appropriate temperature. Further, in the present embodiment, the supply amount of the liquid medium LM is controlled such that the liquid medium LM is positioned near the downstream portion of the screw conveyance machine 11. In this manner, when the fluid medium Fa is brought into contact with the liquid medium LM to be cooled, the temperature of the fluid medium Fa is set to an appropriate temperature in the upstream portion of the screw conveyance machine 11, and accordingly, it is possible to appropriately cause peeling of the coating layer caused by the shrinkage difference between the fluid medium Fa and the coating layer in the downstream portion of the screw conveyance machine 11, and it is possible to

prevent cracks from occurring in the fluid medium Fa itself due to excessive rapid cooling. The appropriate temperature is appropriately selected from the temperatures equal to or higher than the room temperature (for example, 25°C) and equal to or lower than the melting point of the coating layer of the fluid medium (the melting point is 700°C or lower as long as the coating layer is a coating layer of $\text{SiO}_2\text{-K}_2\text{O}$), depending on the temperature and supply amount of the liquid medium, the charge amount of the fluid medium Fa, and the like.

[0053]

According to the fluid medium regeneration device 22 according to the second embodiment described above, the high-temperature fluid medium Fa is cooled to an appropriate temperature by the cooling medium flow path 23 and then brought into contact with the liquid medium LM, and accordingly, it is possible to suppress excessive evaporation of the liquid medium LM or a large change in temperature due to charging of the fluid medium Fa. As a result, it is possible to avoid a situation in which a large amount of the liquid medium LM is supplied in order to suppress a temperature change of the liquid medium LM or the temperature inside the screw conveyance machine 11 is frequently adjusted, and accordingly, it is possible to

reduce the size of the screw conveyance machine 11 and the operation cost.

[0054]

In the combustion system 21 of the second embodiment, in the fluid medium regeneration device 22, the cooling medium flow path 23 is installed around the upstream portion of the screw conveyance machine 11, but the present invention is not limited to this configuration. For example, the fluid medium regeneration device 22 may be configured such that the cooling medium flow path 23 is installed around the downstream portion of the screw conveyance machine 11 and the liquid medium LM may be supplied from the periphery of the upstream portion of the screw conveyance machine 11.

[0055]

(Combustion Method of Fluidized Bed Combustion Furnace)

Further, a flow of a combustion method of a fluidized bed combustion furnace applicable to the above-described combustion system and fluid medium regeneration device will be described with reference to the drawings. Fig. 5 is a flow chart for describing the combustion method applicable to the combustion system and the fluid medium regeneration device according to the present embodiment.

[0056]

As described above, the combustion method of the fluidized bed combustion furnace in the present embodiment is the combustion method of the fluidized bed combustion furnace using the alkaline-containing fuel such as biomass fuel. In the combustion method of the present embodiment has a process in which, first, an alkaline-containing fuel such as biomass fuel is burned into a fluidized bed combustion furnace (combustion process in step S1), a fluid medium is recovered from the fluidized bed of the fluidized bed combustion furnace (recovery process in step S2), the fluid medium recovered from the fluidized bed is cooled by being brought into contact with a liquid medium having a boiling point of -20°C or lower under 1 atmospheric pressure, and the coating layer is separated from the fluid medium (cooling separation process in step S3). Specifically, this is a process of bringing the fluid medium Fa recovered from the combustion furnace 2 in Fig. 1 into contact with the liquid medium LM in the screw conveyance machine 11. In this case, the liquid medium is not particularly limited, but can be at least one of liquid air and liquid nitrogen as described above.

[0057]

In addition, in the cooling separation process, as described above, the temperature of the fluid medium recovered from the fluidized bed of the fluidized bed

combustion furnace is preferably equal to or lower than the melting point of the coating layer of the fluid medium.

Therefore, as described in the second embodiment, in the cooling separation process, the fluid medium may be cooled by the intermediate cooling unit (for example, the cooling medium flow path 23 in Fig. 4) and then brought into contact with the liquid medium.

[0058]

Next, the fluid medium and the coating layer separated in the cooling separation process can be sorted in the sorting process (sorting process in step S4). Specifically, the fluid medium Fa and the coating layer supplied to the sorting device 12 in Fig. 1 are sorted by a sieve in the device, and a combustion-unsuitable material such as a coating layer is exhausted to the outside of the system.

[0059]

In addition, in the present embodiment, it is possible to include a return process of recovering the fluid medium from which the coating layer has been separated and returning the fluid medium having a particle size adjusted to 50 to 1,000 μm to the fluidized bed (step S6 in Fig. 5). In addition, in the present embodiment, as shown in Fig. 5, it is possible to include a particle size adjustment process prior to the return process such that the particle size of the recovered fluid medium is adjusted to 50 to

1,000 μm and then the fluid medium is returned to the fluidized bed (step S5 in Fig. 5).

[0060]

According to the combustion method in the present embodiment described above, similar to the combustion system and the fluid medium regeneration device described above, by bringing the high-temperature fluid medium Fa extracted from the bottom portion of the fluidized bed F of the combustion furnace 2 into contact with the liquid medium having a boiling point of -20°C or lower under 1 atmospheric pressure, and by rapidly cooling the fluid medium Fa, efficient separation between the fluid medium and the coating layer is realized. Therefore, it is possible to ensure the quality of the fluid medium which is the circulation material and achieve effective utilization.

[0061]

Further, according to the combustion method in the present embodiment, the fluid medium separated from the coating layer can be recovered and returned to the fluidized bed by the return process, and thus it is possible to return the fluid medium extracted from the fluidized bed and automatically replenish the fluid medium, and it is possible to reduce the labor related to the replenishment of the fluid medium.

[0062]

In addition, according to the combustion method in the present embodiment, since the particles of the fluid medium can be handled in a dry state, the conveyance of the fluid medium in the sorting process and the return process is smooth, and the recycling of the fluid medium becomes easy. At the same time, it is possible to reduce the amount of moisture brought in when the fluid medium is returned to the fluidized bed in the fluidized bed combustion furnace. Further, according to the combustion method in the present embodiment, the fluid medium can be returned to the fluidized bed combustion furnace without going through a drying process or the like, and thus, it is possible to suitably apply the fluid medium to a large-sized combustion furnaces that use a large amount of fluid medium (such as sand).

[0063]

The fluid medium regeneration device, the combustion system, and the combustion method of the present invention are not limited to the above-described embodiments.

[0064]

For example, the present invention is also applicable to a fluidized bed combustion furnace other than the CFB boiler. Further, the fuel used in the combustion furnace is not limited to the biomass fuel. Any fuel may be used as long as the fuel has a sufficient shrinkage difference

between the coating layer and the fluid medium Fa. In particular, the present invention can be suitably applied to a case where a fuel containing a highly alkaline component is used.

[0065]

In addition, the above-described intermediate cooling means is not limited to the cooling medium flow path 23 described in the second embodiment, and may have an aspect of cooling the fluid medium Fa by, for example, air cooling. In addition, the heat recovered in the cooling medium flow path 23 may be used in other facilities. In addition, the return line 13B does not necessarily have to be provided.

[0066]

Further, in the combustion systems of the first and second embodiments, the configuration in which the liquid medium LM is supplied from the supply pipe 11A to the screw conveyance machine 11 and comes into contact with the fluid medium Fa in the screw conveyance machine 11 has been described, but the present invention is not limited to this aspect. For example, as in a fluid medium regeneration device 31 of a combustion system 30 shown in Fig. 6, a cooling unit 33 to which the liquid medium LM is separately supplied may be provided on the downstream side of a screw conveyance machine 32. The fluid medium regeneration device

31 may be configured such that the fluid medium Fa conveyed from the screw conveyance machine 32 comes into contact with the liquid medium LM in the cooling unit 33 and is cooled, and the coating layer is separated by the cooling. In the fluid medium regeneration device 31, the screw conveyance machine 32 can play the role of the intermediate cooling unit.

[0067]

In addition, all the documents, patent applications, and technical standards described in the specification are to the same extent as in the case where it is specifically and individually stated that the individual documents, patent applications, and technical standards are incorporated by reference in the present specification.

Reference Signs List

[0068]

- 1, 21, 30 Combustion system
- 2 Combustion furnace (fluidized bed combustion furnace)
- 3, 22, 31 Fluid medium regeneration device
- 11 Screw conveyance machine (cooling unit)
- 33 Cooling unit
- 12 Sorting device (sorting unit)
- 13 Return mechanism (return unit)

23 Cooling medium flow path (intermediate cooling
unit)

F Fluidized bed

CLAIMS

1. A fluid medium regeneration device for a fluidized bed, comprising:

a cooling unit that is supplied with at least, a fluid medium recovered from the fluidized bed of a fluidized bed combustion furnace is supplied, cools the fluid medium by being brought into contact with a liquid medium having a boiling point of -20°C or lower under 1 atmospheric pressure, and separates a coating layer from the fluid medium.

2. The fluid medium regeneration device for a fluidized bed according to claim 1, wherein

the liquid medium is at least one of liquid air, liquid nitrogen, and liquid oxygen.

3. The fluid medium regeneration device for a fluidized bed according to claim 1 or 2, further comprising:

sorting means that sorts the fluid medium exhausted from the cooling unit, and the coating layer.

4. The fluid medium regeneration device for a fluidized bed according to any one of claims 1 to 3, wherein

a temperature of the fluid medium recovered from the fluidized bed of the fluidized bed combustion furnace is equal to or lower than a melting point of the coating layer.

5. The fluid medium regeneration device for a fluidized bed according to any one of claims 1 to 4, wherein

the cooling unit includes an intermediate cooling unit that further cools the fluid medium, and brings the fluid medium cooled by the intermediate cooling unit into contact with the liquid medium.

6. The fluid medium regeneration device for a fluidized bed according to any one of claims 1 to 5, further comprising:

a return unit that recovers the fluid medium from which the coating layer has been separated, and returns the fluid medium having a particle size adjusted to 50 to 1,000 μm to the fluidized bed.

7. A combustion system comprising:

a fluidized bed combustion furnace; and
the fluid medium regeneration device for a fluidized bed according to any one of claims 1 to 6.

8. A combustion method of a fluidized bed combustion furnace using an alkaline-containing fuel, the combustion method comprising:

recovering the fluid medium from the fluidized bed of the fluidized bed combustion furnace, cooling the fluid medium recovered from the fluidized bed by being brought into contact with a liquid medium having a boiling point of -20°C or lower under 1 atmospheric pressure, and separating a coating layer from the fluid medium.

9. The combustion method of a fluidized bed combustion furnace according to claim 8, wherein

the liquid medium is at least one of liquid air and liquid nitrogen.

10. The combustion method of a fluidized bed combustion furnace according to claim 8 or 9, wherein the fluid medium and the coating layer are sorted.

11. The combustion method of a fluidized bed combustion furnace according to any one of claims 8 to 10, wherein

a temperature of the fluid medium recovered from the fluidized bed of the fluidized bed combustion furnace is equal to or lower than a melting point of the coating layer.

12. The combustion method of a fluidized bed combustion furnace according to any one of claims 8 to 11, wherein

the fluid medium is cooled by an intermediate cooling unit and then brought into contact with the liquid medium.

13. The combustion method of a fluidized bed combustion furnace according to any one of claims 8 to 12, wherein

the fluid medium from which the coating layer has been separated is recovered, and the fluid medium having a particle size adjusted to 50 to 1,000 μm is returned to the fluidized bed.