AUTO-IGNITION PREVENTION DEVICE

Field

[0001] The present disclosure relates to an auto-ignition prevention device that prevents auto-ignition of flammable gas in a pipe.

Background

[0002] For example, in a garbage incinerator, an integrated coal gasification combined cycle power generation plant (IGCC), and a power generation boiler, dust contained in flue gas adheres to the inner wall surface of a furnace, the outer surface of a heat transfer pipe, and the like. Dust adhering to the inner wall surface of the furnace, the outer surface of the heat transfer pipe, and the like degrades heat recovery efficiency through reduction of the heat-transfer rate, and decreases the performance of the furnace through resistance against flow of the flue gas.

[0003] Patent Literature 1 below discloses an exemplary device that removes dust adhering to the inner wall of the furnace and the outer surface of the heat transfer pipe. In the dust removal device disclosed in Patent Literature 1, a pipe communicating with the inside of the furnace is filled with flammable gas, and the flammable gas is ignited to generate a detonation shock wave. With the dust removal device, the shock wave acts on the inner wall surface of the furnace and the outer surface of the heat transfer pipe and blows off and removes dust adhering thereto.

Citation List

Patent Literature

[0004] Patent Literature 1: U.S. Patent Application Laid-open No. 2005/0126594

Summary

Technical Problem

[0005] In a conventional dust removal device, a plurality of partition valves are disposed at a pipe, and when the device is not actuated, the partition valves are moved to close positions to prevent auto-ignition of flammable gas filling the pipe. However, in a case in which the inner diameter of the pipe is large, the sizes of the valves are large, which leads to increase of component cost and maintenance cost. Furthermore, since the partition valves are disposed in a high-temperature environment, an actuation defect potentially occurs to the valves, and thus it is difficult to appropriately prevent auto-ignition of the flammable gas.

[0006] The present disclosure is intended to solve the above-described problem, and an object of the present disclosure is to provide an auto-ignition prevention device that prevents increase of component cost and maintenance cost and appropriately prevents auto-ignition of flammable gas.

Solution to Problem

[0007] An auto-ignition prevention device according to the present disclosure includes: a pipe to be filled with flammable gas, the pipe being arranged to communicate with a target region; an expanding pipe having an inner diameter larger than an inner diameter of the pipe and arranged between the pipe and the target region; and an ejection part configured to eject non-flammable gas from an outer peripheral part of the expanding pipe toward a central part side.

Advantageous Effects of Invention

[0008] With an auto-ignition prevention device according to the present disclosure, it is possible to prevent increase of component cost and maintenance cost and

appropriately prevent auto-ignition of flammable gas.

Brief Description of Drawings

[0009] FIG. 1 is a sectional view of a furnace, illustrating an auto-ignition prevention device according to a first embodiment.

FIG. 2 is a front view of the auto-ignition prevention device from the furnace side.

FIG. 3 is a sectional view of a furnace, illustrating an auto-ignition prevention device according to a second embodiment.

FIG. 4 is a sectional view of a furnace, illustrating an auto-ignition prevention device according to a third embodiment.

FIG. 5 is a front view of the auto-ignition prevention device viewed from the furnace side.

FIG. 6 is a sectional view of a furnace, illustrating an auto-ignition prevention device according to a fourth embodiment.

FIG. 7 is a sectional view of a furnace, illustrating an auto-ignition prevention device according to a fifth embodiment.

Description of Embodiments

[0010] A preferable embodiment of the present disclosure will be described below in detail with reference to the accompanying drawings. The present disclosure is not limited to the embodiment, but when a plurality of embodiments are provided, the present disclosure also includes combination of the embodiments. Constituent components in the embodiments include those that can be easily thought of by the skilled person in the art, those identical in effect, and what are called equivalents.

[0011] First embodiment

Configuration of auto-ignition prevention device

FIG. 1 is a sectional view of a furnace, illustrating an auto-ignition prevention device according to a first embodiment, and FIG. 2 is a front view of the auto-ignition prevention device from the furnace side.

[0012] The auto-ignition prevention device according to the first embodiment is applied to a dust removal device that removes dust adhering to the inner wall surface of a furnace such as a garbage incinerator, an integrated coal gasification combined cycle power generation plant, or a power generation boiler (hereinafter referred to as a boiler), the outer surface of a heat transfer pipe, and the like. The dust removal device generates a detonation shock wave by supply flammable gas into the furnace through a pipe communicating with the inside of the furnace and igniting the flammable gas. The dust removal device blows off and removes the adhering dust as the detonation shock wave acts on the inner wall of the furnace and the outer surface of the heat transfer pipe.

[0013] The auto-ignition prevention device is provided in the dust removal device to prevent auto-ignition of the flammable gas filling a pipe due to heat of flue gas moving upward inside the furnace during operation of the boiler.

[0014] As illustrated in FIGS. 1 and 2, this auto-ignition prevention device 10 includes a pipe 11, an expanding pipe 12, and an ejection part 13.

[0015] A furnace 101 has a furnace wall 102. The furnace 101 has an internal space 103 partitioned by an inner wall surface 102a of the furnace wall 102. A heat transfer pipe included in a non-illustrated heat exchanger is disposed in the internal space 103 of the furnace 101. High-temperature flue gas G1 flows in a predetermined direction in the internal space 103 of the furnace 101. The flow direction of the high-temperature flue gas G1

varies with the position of the internal space 103, the shapes of surroundings, and the like, but the following description will be made on a case in which the high-temperature flue gas G1 moves upward in the internal space 103.

[0016] The pipe 11 can supply flammable gas G2 to the internal space 103 as a target region. The pipe 11 has, for example, a cylindrical shape of a constant inner diameter in the longitudinal direction. However, the pipe 11 is not limited to such a cylindrical shape but may have a polygonal tubular shape. One end part of the pipe 11 in the axial direction is coupled to a supply device (not illustrated) of the flammable gas G2, and the other end part thereof is coupled to the expanding pipe 12.

[0017] The expanding pipe 12 is provided between the pipe 11 and the furnace wall 102 (internal space 103) of the furnace 101. The inner diameter of the expanding pipe 12 on the furnace wall 102 side is larger than the inner diameter of the pipe 11. The diameter of the expanding pipe 12 continuously and uniformly increases from the pipe 11 side toward the furnace wall 102 (internal space 103) side. Specifically, one end part of the expanding pipe 12 in the axial direction has the same diameter as the pipe 11 and is coupled to the other end part of the pipe 11. The diameter of the expanding pipe 12 gradually increases from the one end part toward the other end part in the axial direction, and the expanding pipe 12 is coupled to the furnace wall 102. A coupling part of the expanding pipe 12 with the furnace wall 102 may be freely movable because reaction force of a detonation shock wave of the flammable gas G2 inside acts on the expanding pipe 12.

[0018] The ejection part 13 ejects non-flammable gas G3 from an outer peripheral part of the expanding pipe 12

toward a central part side. The ejection part 13 is provided on the other end part side, in other words, the furnace 101 (the internal space 103) side in the expanding pipe 12.

[0019] An outer cylindrical pipe 21 is disposed outside the other end part side of the expanding pipe 12. The outer cylindrical pipe 21 has a cylindrical shape of a diameter that is larger than that of the expanding pipe 12 and, similarly to the expanding pipe 12, continuously and uniformly increases from one end part toward the other end part in the axial direction. The outer cylindrical pipe 21 is disposed with a gap between the inner peripheral surface thereof and the outer peripheral surface of the expanding pipe 12, and the outer peripheral surface thereof is fitted and fixed to a through-hole 102b of the furnace wall 102. Thus, the other end part side of the expanding pipe 12 is disposed inside the furnace wall 102, and the outer cylindrical pipe 21 is entirely disposed inside the furnace wall 102. Similarly to the expanding pipe 12, the outer cylindrical pipe 21 may be freely movably coupled to the furnace wall 102.

[0020] The outer cylindrical pipe 21 includes an outer barrel part 21a and a flange part 21b. The outer barrel part 21a is disposed with a gap to the outer peripheral surface of the expanding pipe 12. The flange part 21b is disposed on the other end part side in the axial direction on the outer cylindrical pipe 21, has an outer peripheral part coupled to the other end part of the outer barrel part 21a, and an inner peripheral part coupled to the other end part of the expanding pipe 12. Accordingly, a gas flow part 22 having a cylindrical shape is formed between the expanding pipe 12 and the outer cylindrical pipe 21.

[0021] A header 23 is disposed on the one end part side

in the axial direction on the outer cylindrical pipe 21. The header 23 has a ring shape and an L sectional shape. One end part of the header 23 in the width direction is fixed to an outer wall surface 102c of the furnace wall 102, and the other end part thereof is fixed to the outer peripheral surface of the expanding pipe 12. Accordingly, the header 23 partitions a gas space part 24 in a ring shape between the furnace wall 102 and the expanding pipe 12. The gas space part 24 communicates with the gas flow part 22 on the one end part side. Similarly to the expanding pipe 12 and the outer cylindrical pipe 21, the header 23 may be freely movably coupled to the furnace wall 102. The header 23 may be fixed to the outer cylindrical pipe 21 to partition the gas space part 24.

[0022] The ejection part 13 includes a plurality (in the present embodiment, eight) of ejection holes 31 through which the non-flammable gas G3 is ejected. The ejection holes 31 are formed on the other end part side in the axial direction in the expanding pipe 12, in other words, on the internal space 103 side of the furnace 101. Each ejection hole 31 is an opening having a slit shape extending in the circumferential direction of the expanding pipe 12. However, the number of ejection holes 31 is not limited. The ejection holes 31 are not limited to such a slit shape but may be circular holes.

[0023] The ejection holes 31 of the ejection part 13 eject the non-flammable gas G3 in a tilt direction tilted on the internal space 103 side of the furnace 101 relative to the radial direction of the expanding pipe 12. Specifically, the diameter of the expanding pipe 12 increases from the one end part toward the other end part. The ejection holes 31 orthogonally penetrate through the other end part of the expanding pipe 12 having the

increasing diameter. Accordingly, the ejection holes 31 ejects the non-flammable gas G3 from the outer peripheral part of the expanding pipe 12 toward the internal space 103 side.

[0024] The expanding pipe 12 is set to a predetermined increase ratio. For example, the expanding pipe 12 is preferably set to an area ratio $(R2/2)^2\pi/(R1/2)^2\pi$ of 1.4 to 4.0 where R1 represents the inner diameter on the one end part side and R2 represents the inner diameter on the other end part side. The expanding pipe 12 is also preferably set to an angle α of 10° to 50° between the inner surface and the central line. The ejection holes 31 are preferably set such that the non-flammable gas G3 has an ejection angle β of 0° to 45° relative to the radial direction of the expanding pipe 12.

[0025] One end part of a gas supply line 26 is coupled to the header 23 through a port 25. The other end part of the gas supply line 26 is coupled to a gas supply source 27, and an on-off valve 28 is provided at a middle part thereof. The gas supply source 27 is, for example, an air blower or a compressor and supplies air or compressed air as the non-flammable gas G3. However, the gas supply source 27 is not limited to this configuration. For example, the non-flammable gas G3 may be gas having a lower oxygen fraction than air, or inert gas (such as nitrogen or argon) instead of air, and the gas supply source 27 may be, for example, a tank in which these gasses are stored.

[0026] Accordingly, when the on-off valve 28 is opened, the non-flammable gas G3 is supplied from the gas supply source 27 to the gas supply line 26 and supplied to the gas space part 24 through the port 25. The non-flammable gas G3 supplied to the gas space part 24 flows through the gas flow part 22 to the other end part side of the expanding

pipe 12 and is ejected to the central part side of the expanding pipe 12 through the ejection holes 31.

[0027] <Effects of auto-ignition prevention device>

The dust removal device actuates when dust adheres to, for example, the inner wall surface 102a of the furnace wall 102 and the heat transfer pipe (not illustrated) of the heat exchanger in the furnace 101 through long-period use. Specifically, the supply device supplies the flammable gas G2 to the pipe 11, fills the pipe 11 with the flammable gas G2, and ignites the flammable gas G2. Then, the flammable gas G2 combusts inside the pipe 11 and generates a detonation shock wave. The generated shock wave is transferred to the internal space 103 through the pipe 11 and the expanding pipe 12 and acts on the inner wall surface 102a of the furnace wall 102 and the outer surface of the heat transfer pipe, and accordingly, the adhering dust is blown off and removed. In this process, since the detonation shock wave generated in the pipe 11 is transferred to the internal space 103 of the furnace 101 through the expanding pipe 12 having the increasing diameter, supersonic flow ejected together with blast can be expanded at an appropriate area ratio and blast and jet can be efficiently introduced into the internal space 103. The actuation of the dust removal device is stopped when the dust adhering to the inner wall surface 102a of the furnace wall 102 and the outer surface of the heat transfer pipe is removed by the dust removal device.

[0028] At the dust removal by the dust removal device described above, auto-ignition potentially occurs to the flammable gas G2 filling the pipe 11 and the expanding pipe 12. Thus, the auto-ignition prevention device 10 is actuated when the dust removal device is actuated. Specifically, the on-off valve 28 is opened to supply the

non-flammable gas G3 from the gas supply source 27 to the gas space part 24 through the gas supply line 26. Accordingly, the non-flammable gas G3 filling the gas space part 24 flows through the gas flow part 22 to the other end part side of the expanding pipe 12 and is ejected to the central part side of the expanding pipe 12 through the ejection holes 31.

[0029] Simultaneously, the ejection part 13 ejects the non-flammable gas G3 toward the central part side of the expanding pipe 12 through the ejection holes 31, thereby forming an air curtain between the inside of the expanding pipe 12 and the internal space 103 of the furnace 101. The air curtain of the non-flammable gas G3 provides a partition between the inside of the expanding pipe 12 and the internal space 103, and accordingly, for example, the flue gas G1 moving upward inside the internal space 103 is prevented from infiltrating into the expanding pipe 12. Thus, the flammable gas G2 filling the pipe 11 is prevented from auto-igniting due to contact with the high-temperature flue gas G1.

[0030] However, part of the flue gas G1 slips by the air curtain of the non-flammable gas G3 due to, for example, the flow velocity and drift of the flue gas G1 moving upward inside the internal space 103, and potentially infiltrates into the expanding pipe 12. In this case, since the inner diameter (area) of the expanding pipe 12 is larger on the furnace wall 102 side than on the pipe 11 side, the flue gas G1 having infiltrated into the expanding pipe 12 from the internal space 103 becomes secondary flow F that rotates in the anticlockwise direction in FIG. 1 in the expanding pipe 12. Thus, the flue gas G1 having entered the expanding pipe 12 rotates and accumulates as the secondary flow F inside the expanding pipe 12 and

becomes unlikely to flow to the pipe 11 side, and accordingly, auto-ignition of the flammable gas G2 filling the pipe 11 is prevented.

[0031] Even when part of the flue gas G1 having entered the expanding pipe 12 contacts the flammable gas G2 filling the pipe 11, the temperature of the flue gas G1 decreases while the flue gas G1 flows through the expanding pipe 12. Accordingly, the flammable gas G2 in the pipe 11 is diluted through mixture with the flue gas G1 having the decreased temperature and does not auto-ignite, and the concentration thereof decreases. Thus, auto-ignition of the flammable gas G2 is prevented even when mixed gas of the flammable gas G2 and the flue gas G1 flows back to the internal space 103 through the expanding pipe 12.

[0032] In the above description, the auto-ignition prevention device 10 is actuated when dust adhering to the inner wall surface 102a of the furnace wall 102 and the outer surface of the heat transfer pipe is removed by the dust removal device, but the present invention is not limited to this configuration. The auto-ignition prevention device 10 may be constantly actuated.

[0033] Second embodiment

FIG. 3 is a sectional view of a furnace, illustrating an auto-ignition prevention device according to a second embodiment. Any member having the same function as in the above-described first embodiment is denoted by the same reference sign, and detailed description thereof will be omitted.

[0034] As illustrated in FIG. 3, this auto-ignition prevention device 10A in the second embodiment includes the pipe 11, the expanding pipe 12, and an ejection part 13A.

[0035] The expanding pipe 12 is provided between the pipe 11 and the internal space 103 of the furnace 101. The

one end part of the expanding pipe 12 has the same diameter as the pipe 11 and is coupled to the other end part of the pipe 11, the diameter gradually increases toward the other end part, and the other end part is coupled to the furnace wall 102. The ejection part 13A ejects non-flammable gasses G3 and G4 from the outer peripheral part of the expanding pipe 12 toward the central part side. The ejection part 13 has a plurality of first ejection holes 31 and a plurality of second ejection holes 32. The first ejection holes 31 are provided on the furnace 101 (the internal space 103) side in the expanding pipe 12 and eject the non-flammable gas G3. The second ejection holes 32 are provided on the pipe 11 side in the expanding pipe 12 and eject the non-flammable gas G4. The first ejection holes 31 and the second ejection holes 32 of the ejection part 13 eject the non-flammable gas G3 in a tilt direction tilted on the internal space 103 side of the furnace 101 relative to the radial direction of the expanding pipe 12.

[0036] The outer cylindrical pipe 21 is disposed outside the other end part side of the expanding pipe 12, and the gas flow part 22 having a cylindrical shape is formed between the expanding pipe 12 and the outer cylindrical pipe 21. The header 23 is disposed on the one end part side in the axial direction on the outer cylindrical pipe 21. The header 23 partitions the gas space part 24 communicating with the gas flow part 22 and the second ejection holes 32. The one end part of the gas supply line 26 is coupled to the header 23 through the port 25. The other end part of the gas supply line 26 is coupled to the gas supply source 27, and the on-off valve 28 is provided at the middle part thereof.

[0037] Accordingly, when the auto-ignition prevention device 10 is actuated, the non-flammable gas G3 is supplied

from the gas supply line 26 to the gas space part 24 and ejected to the central part side of the expanding pipe 12 through the second ejection holes 32. The non-flammable gas G3 flows through the gas flow part 22 from the gas space part 24 to the other end part side of the expanding pipe 12 and is ejected to the central part side of the expanding pipe 12 through the first ejection holes 31.

[0038] Simultaneously, the first ejection holes 31 eject the non-flammable gas G3 toward the central part side on the other end part side in the expanding pipe 12, thereby forming an air curtain between the inside of the expanding pipe 12 and the internal space 103 of the furnace 101. The second ejection holes 32 eject the non-flammable gas G4 toward the central part side on the one end part side in the expanding pipe 12, thereby forming an air curtain between the inside of the expanding pipe 12 and the inside of the pipe 11. The two air curtains of the non-flammable gas G3 provide partitions between the inside of the pipe 11, the inside of the expanding pipe 12, and the internal space 103. The air curtain of the non-flammable gas G3 partitions the inside of the expanding pipe 12 and the internal space 103. The air curtain of the non-flammable gas G4 partitions the inside of the pipe 11 and the inside of the expanding pipe 12. The air curtain of the non-flammable gas G3 prevents the flue gas G1 moving upward inside the internal space 103 from infiltrating into the expanding pipe 12. The air curtain of the non-flammable gas G4 prevents the flammable gas G2 inside the pipe 11 from infiltrating into the expanding pipe 12. Accordingly, auto-ignition of the flammable gas G2 filling the pipe 11 due to the flue gas G1 is prevented.

[0039] In the above description, the first ejection holes 31 and the second ejection holes 32 are provided as

the ejection part 13, but the present invention is not limited to this configuration. For example, the ejection part 13 may be constituted by the second ejection holes 32 only.

[0040] Third embodiment

FIG. 4 is a sectional view of a furnace, illustrating an auto-ignition prevention device according to a third embodiment, and FIG. 5 is a front view of the auto-ignition prevention device viewed from the furnace side. Any member having the same function as in the above-described first embodiment is denoted by the same reference sign, and detailed description thereof will be omitted.

[0041] As illustrated in FIGS. 4 and 5, this auto-ignition prevention device 10B in the third embodiment includes the pipe 11, the expanding pipe 12, and an ejection part 13B.

[0042] The expanding pipe 12 is provided between the pipe 11 and the internal space 103 of the furnace 101. The one end part of the expanding pipe 12 has the same diameter as the pipe 11 and is coupled to the other end part of the pipe 11, the diameter gradually increases toward the other end part, and the other end part is coupled to the furnace wall 102. The ejection part 13B ejects non-flammable gasses G3a and G3b from the outer peripheral part of the expanding pipe 12 toward the central part side. The ejection part 13B includes a plurality of upstream ejection holes (upstream ejection part) 31a and a plurality of downstream ejection holes (downstream ejection part) 31b. The upstream ejection holes 31a and the downstream ejection holes 31b are provided on the furnace 101 side in the expanding pipe 12 and eject the non-flammable gasses G3a and G3b, respectively.

[0043] The upstream ejection holes 31a are disposed

upstream (the lower side in FIG. 4) in the flow direction of the flue gas G1 moving upward inside the internal space 103 of the furnace 101. The downstream ejection holes 31b are disposed downstream (the upper side FIG. 4) in the flow direction of the flue gas G1 moving upward inside the internal space 103 of the furnace 101. In the present embodiment, four upstream ejection holes 31a are disposed on the lower side in the expanding pipe 12 and four downstream ejection holes 31b are disposed the upper side in the expanding pipe 12, but the numbers thereof are not limited and may be different from each other. The ejection amount of the non-flammable gas G3b from the downstream ejection holes 31b is larger than the ejection amount of the non-flammable gas G3a from the upstream ejection holes 31a. Specifically, the deviation of the dynamic pressures of air curtains of the non-flammable gasses G3a and G3b, which is the deviation of the flow rates thereof, is preferably, for example, equal to or higher than 0.5 times the dynamic pressure of the flue gas G1 moving upward inside the internal space 103.

[0044] The outer cylindrical pipe 21 is disposed outside the other end part side of the expanding pipe 12, and gas flow parts 22a and 22b each having a cylindrical shape are formed between the expanding pipe 12 and the outer cylindrical pipe 21. Partition plates 21c are provided on the inner surface of the outer cylindrical pipe 21 on both sides in the horizontal direction, thereby partitioning the gas flow part 22a on the lower side and the gas flow part 22b on the upper side. The header 23 is provided at one end part of the outer cylindrical pipe 21 in the axial direction. The header 23 partitions gas space parts 24a and 24b communicating with the gas flow parts 22a and 22b. Partition plates (not illustrated) are provided on the

inner surface of the header 23 on both sides in the horizontal direction, thereby partitioning the gas space part 24a on the lower side and the gas space part 24b on the upper side. The gas flow part 22a communicates with the gas space part 24a, and the gas flow part 22b communicates with the gas space part 24b. One end part of a gas supply line 26a is coupled to the header 23 through a port 25a communicating with the gas space part 24a, and the other end part thereof is coupled to the gas supply source 27. One end part of a gas supply line 26b is coupled to the header 23 through a port 25b communicating with the gas space part 24b, and the gas supply source 27 is coupled to the other end part. On-off valves 28a and 28b are provided at middle parts of the gas supply lines 26a and 26b. The on-off valves 28a and 28b are flow rate adjustment valves.

[0045] Accordingly, when the auto-ignition prevention device 10 is actuated, the non-flammable gasses G3a and G3b are supplied from the gas supply lines 26a and 26b to the gas space parts 24a and 24b and flow through the gas flow parts 22a and 22b to the other end part side of the expanding pipe 12. Then, the non-flammable gas G3a is ejected to the central part side of the expanding pipe 12 through the upstream ejection holes 31a, and the non-flammable gas G3b is ejected to the central part side of the expanding pipe 12 through the downstream ejection holes 31b.

[0046] Specifically, the upstream ejection holes 31a eject the non-flammable gas G3a along the flue gas G1 moving upward inside the internal space 103, and the downstream ejection holes 31b eject the non-flammable gas G3a against the flue gas G1 moving upward inside the internal space 103. Simultaneously, the opening degrees of the on-off valves 28a and 28b are adjusted so that the

ejection amount of the non-flammable gas G3b from the downstream ejection holes 31b is larger than the ejection amount of the non-flammable gas G3a from the upstream ejection holes 31a.

[0047] Part of the flue gas G1 moving upward inside the internal space 103 slips by the air curtain of the non-flammable gas G3 due to, for example, flow velocity and drift and potentially infiltrates into the expanding pipe 12. Then, the flue gas G1 having infiltrated into the expanding pipe 12 from the internal space 103 becomes the secondary flow F that rotates in the anticlockwise direction in FIG. 4 in the expanding pipe 12. The downstream ejection holes 31b eject a large amount of the non-flammable gas G3b against the flow of the flue gas G1 infiltrating into the expanding pipe 12 from the internal space 103. Accordingly, the large amount of the non-flammable gas G3b encumbers flow of the flue gas G1 infiltrating into the expanding pipe 12 from the internal space 103 and can prevent the flue gas G1 from entering the expanding pipe 12, thereby preventing auto-ignition of the flammable gas G2 filling the pipe 11.

[0048] In the above description, the upstream ejection holes 31a and the downstream ejection holes 31b are provided as the ejection part 13B and the ejection amount of the non-flammable gas G3a from the upstream ejection holes 31a is different from the ejection amount of the non-flammable gas G3b from the downstream ejection holes 31b, but the present invention is not limited to this configuration. For example, the number of kinds of ejection holes having different ejection amounts is not limited to two but may be three or more.

[0049] Fourth embodiment

FIG. 6 is a sectional view of a furnace, illustrating

an auto-ignition prevention device according to a fourth embodiment. Any member having the same function as in the above-described first embodiment is denoted by the same reference sign, and detailed description thereof will be omitted.

[0050] As illustrated in FIG. 6, this auto-ignition prevention device 10C in the fourth embodiment includes the pipe 11, the expanding pipe 12, and the ejection part 13. The auto-ignition prevention device 10C can adjust the flow rate of the non-flammable gas G3 sprayed by the ejection part 13 in accordance with a property of the flammable gas G2 or the like. The property of the flammable gas G2 is, for example, the flow rate of the flammable gas G2 flowing through the pipe 11.

[0051] A flow rate sensor 41 configured to measure the flow rate of the flammable gas G2 is provided inside the pipe 11. A control unit 42 adjusts the opening degree of the on-off valve 28 based on the flow rate of the flammable gas G2 detected by the flow rate sensor 41. The control unit 42 adjusts to increase the opening degree of the on-off valve 28 as the flow rate of the flammable gas G2 flowing through the pipe 11 is higher. In other words, the ejection part 13 increases the flow rate of the non-flammable gas G3 sprayed from the ejection holes 31 as the flow rate of the flammable gas G2 flowing through the pipe 11 is higher.

[0052] In the above description, a detection unit configured to detect the property of the flammable gas G2 is not limited to the flow rate sensor 41. Examples of applicable detection units configured to detect properties such as the flow velocity and concentration of the flammable gas G2 include a speed sensor configured to detect the flow velocity of the flammable gas G2, a

concentration sensor configured to detect the concentration of the flammable gas G2, sensors for a set supply amount of the flammable gas G2 and the opening degree of a valve in the supply device, a sampling measurement device for the flammable gas G2, and a laser instrumentation device. A map on which the injection amount of the non-flammable gas G3 is set for the set supply amount of the flammable gas G2 in the supply device may be prepared in advance, and the opening degree of the on-off valve 28 may be adjusted based on the map.

[0053] Fifth embodiment

FIG. 7 is a sectional view of a furnace, illustrating an auto-ignition prevention device according to a fifth embodiment. Any member having the same function as in the above-described first embodiment is denoted by the same reference sign, and detailed description thereof will be omitted.

[0054] As illustrated in FIG. 7, this auto-ignition prevention device 10D in the fifth embodiment includes the pipe 11, the expanding pipe 12, and the ejection part 13. The auto-ignition prevention device 10C can adjust the flow rate of the non-flammable gas G3 sprayed by the ejection part 13 in accordance with a property of the flue gas G1 or the like. The property of the flue gas G1 is, for example, the temperature of the flue gas G1 infiltrating into the pipe 11.

[0055] A temperature sensor 43 configured to measure the temperature of the flue gas G1 is provided inside the expanding pipe 12. The control unit 42 adjusts the opening degree of the on-off valve 28 based on the temperature of the flue gas G1 detected by the temperature sensor 43. The control unit 42 adjusts to increase the opening degree of the on-off valve 28 as the temperature of the flue gas G1

having entered the expanding pipe 12 is higher. In other words, the ejection part 13 increases the flow rate of the non-flammable gas G3 sprayed from the ejection holes 31 as the temperature of the flue gas G1 having entered the expanding pipe 12 is higher.

[0056] In the above description, a detection unit configured to detect the property of the flue gas G1 is not limited to the temperature sensor 43. Examples of applicable detection units configured to detect the property of the flue gas G1 include a temperature sensor configured to detect the temperature of the inner peripheral surface of the expanding pipe 12, a temperature sensor configured to detect the temperature of the flue gas G1 moving upward inside the internal space 103, a temperature sensor configured to detect the temperature of the inner wall surface 102a of the furnace wall 102, and a flow rate sensor (speed sensor) configured to detect the flow rate (flow velocity) of the flue gas G1 having entered the expanding pipe 12. A map on which the injection amount of the non-flammable gas G3 is set for the temperature of the flue gas G1 having entered the expanding pipe 12 may be prepared in advance, and the opening degree of the on-off valve 28 may be adjusted based on the map. PID control may be executed based on the detected property of the flue gas G1 to adjust the opening degree of the on-off valve 28.

[0057] Effects of the present embodiments

An auto-ignition prevention device according to a first aspect includes the pipe 11 that can be filled with the flammable gas G2 and communicate with the internal space (target region) 103 of the furnace 101, the expanding pipe 12 having an inner diameter larger than the inner diameter of the pipe 11 and provided between the pipe 11 and the furnace wall 102 (internal space 103), and the

ejection part 13, 13A, or 13B that ejects the non-flammable gas G3 from the outer peripheral part of the expanding pipe 12 toward the central part side.

[0058] With the auto-ignition prevention device according to the first aspect, when the pipe 11 is filled with the flammable gas G2, the ejection part 13A or 13B ejects the non-flammable gas G3 from the outer peripheral part of the expanding pipe 12 toward the central part side, thereby forming an air curtain between the expanding pipe 12 and the internal space 103 of the furnace 101. The air curtain of the non-flammable gas G3 partitions the inside of the expanding pipe 12 and the internal space 103 and thus can prevent the flue gas G1 from infiltrating into the expanding pipe 12, thereby preventing auto-ignition of the flammable gas G2 filling the pipe 11 due to the flue gas G1.

[0059] Part of the flue gas G1 slips by the air curtain of the non-flammable gas G3 and potentially infiltrates into the expanding pipe 12. This flue gas G1 forms the secondary flow F that rotates in the expanding pipe 12 and accumulates in the expanding pipe 12. Accordingly, the flue gas G1 is unlikely to flow to the pipe 11 side, thereby preventing auto-ignition of the flammable gas G2 filling the pipe 11.

[0060] Moreover, even when part of the flue gas G1 having entered the expanding pipe 12 contacts the flammable gas G2 filling the pipe 11, the flammable gas G2 is diluted through mixture with the flue gas G1 having a decreased temperature and the concentration of the flammable gas G2 decreases. Accordingly, auto-ignition of the flammable gas G2 is prevented even when the flammable gas G2 diluted through mixture with the flue gas G1 flows back to the internal space 103 through the expanding pipe 12.

[0061] As a result, large-sized valves and the like become unnecessary and increase of component cost and maintenance cost can be prevented. Moreover, the air curtain of the non-flammable gas G3 partitioning the expanding pipe 12 and the internal space 103 can be formed by only providing the ejection part 13 at the expanding pipe 12, is free from an actuation defect when disposed in a high temperature environment, and can appropriately prevent auto-ignition of the flammable gas G2.

[0062] In the auto-ignition prevention device according to a second aspect, the diameter of the expanding pipe 12 continuously increases from the pipe 11 toward the internal space 103. Accordingly, since the diameter of the inner surface of the expanding pipe 12 increases without a step, the flue gas G1 having entered the expanding pipe 12 can appropriately rotate and become the accumulating secondary flow F, thereby preventing auto-ignition of the flammable gas G2 filling the pipe 11.

[0063] In the auto-ignition prevention device according to a third aspect, the ejection part 13, 13A, or 13B ejects the non-flammable gas G3 in a tilt direction tilted on the internal space 103 side relative to the radial direction of the expanding pipe 12. Accordingly, the air curtain of the non-flammable gas G3 is formed with a protrusion toward the internal space 103 side, thereby effectively preventing the flue gas G1 from entering the expanding pipe 12 and the pipe 11 from the internal space 103.

[0064] In the auto-ignition prevention device according to a fourth aspect, the ejection part 13 is provided on the internal space 103 side in the expanding pipe 12. Accordingly, the air curtain of the non-flammable gas G3 can appropriately prevent the flue gas G1 from entering the expanding pipe 12 from the internal space 103.

[0065] In the auto-ignition prevention device according to a fifth aspect, the ejection part 13A is provided on the pipe 11 side in the expanding pipe 12. Accordingly, the air curtain of the non-flammable gas G3 can appropriately prevent the flue gas G1 from entering the pipe 11 from the expanding pipe 12.

[0066] In the auto-ignition prevention device according to a sixth aspect, the ejection part 13B includes the upstream ejection holes (upstream ejection part) 31a disposed upstream in the flow direction of the flue gas G1 flowing through the internal space 103, the downstream ejection holes (downstream ejection part) 31b disposed downstream in the flow direction of the flue gas G1 in the internal space 103, and the ejection amount of the non-flammable gas G3b from the downstream ejection holes 31b is larger than the ejection amount of the non-flammable gas G3a from the upstream ejection holes 31a. Accordingly, a large amount of the non-flammable gas G3b ejected from the downstream ejection holes 31b flows against flow of the flue gas G1 entering the internal space 103, thereby appropriately preventing the flue gas G1 from entering the expanding pipe 12 and the pipe 11 from the internal space 103.

[0067] In the auto-ignition prevention device according to a seventh aspect, the flow rate of the non-flammable gas G3 ejected from the ejection part 13, 13A, or 13B is set in accordance with the property of the flammable gas G2. Accordingly, since the flow rate of the non-flammable gas G3 is set in accordance with flow rate, concentration, or the like as the property of the flammable gas G2, the flue gas G1 can be appropriately prevented from entering the expanding pipe 12 and the pipe 11 from the internal space 103 by the air curtain of the non-flammable gas G3.

[0068] In the auto-ignition prevention device according to an eighth aspect, the flow rate of the non-flammable gas G3 ejected from the ejection part 13, 13A, or 13B is set in accordance with the property of the flue gas G1 in the internal space 103. Accordingly, since the flow rate of the non-flammable gas G3 is set in accordance with temperature, flow rate, or the like as the property of the flue gas G1, the flue gas G1 can be appropriately prevented from entering the expanding pipe 12 and the pipe 11 from the internal space 103 by the air curtain of the non-flammable gas G3.

[0069] In the above-described embodiments, the diameter of the expanding pipe 12 continuously and uniformly increases from its one end part coupled to the pipe 11 toward the other end part coupled to the furnace 101, but the present invention is not limited to this configuration. For example, the diameter of the expanding pipe 12 may discontinuously increase at stages from the one end part toward the other end part.

[0070] In the above-described embodiments, the auto-ignition prevention devices 10, 10A, 10B, 10C, and 10D are applied to a dust removal device such as a garbage incinerator, an integrated coal gasification combined cycle power generation plant, or a power generation boiler but are also applicable to various plants that handle the flammable gas G2.

Reference Signs List

[0071] 10, 10A, 10B, 10C, 10D Auto-ignition prevention device

11 Pipe

12 Expanding pipe

13, 13A, 13B Ejection part

21 Outer cylindrical pipe

22, 22a, 22b Gas flow part
23 Header
24, 24a, 24b Gas space part
25, 25a, 25b Port
26, 26a, 26b Gas supply line
27 Gas supply source
28, 28a, 28b On-off valve
31 Ejection hole, first ejection hole
32 Second ejection hole
31a Upstream ejection hole
31b Downstream ejection hole
41 Flow rate sensor
42 Control unit
43 Temperature sensor
101 Furnace
102 Furnace wall
103 Internal space (target region)
G1 Flue gas
G2 Flammable gas
G3, G3a, G3b, G4 Non-flammable gas
F Secondary flow

CLAIMS

1. An auto-ignition prevention device comprising:

a pipe to be filled with flammable gas, the pipe being arranged to communicate with a target region;

an expanding pipe having an inner diameter larger than an inner diameter of the pipe and arranged between the pipe and the target region; and

an ejection part configured to eject non-flammable gas from an outer peripheral part of the expanding pipe toward a central part side.

2. The auto-ignition prevention device according to claim 1, wherein the expanding pipe has a diameter that continuously increases from the pipe toward the target region.

3. The auto-ignition prevention device according to claim 1 or 2, wherein the ejection part ejects the non-flammable gas in a tilt direction tilted on the target region side relative to a radial direction of the expanding pipe.

4. The auto-ignition prevention device according to any one of claims 1 to 3, wherein the ejection part is provided on the target region side in the expanding pipe.

5. The auto-ignition prevention device according to any one of claims 1 to 4, wherein the ejection part is provided on the pipe side in the expanding pipe.

6. The auto-ignition prevention device according to any one of claims 1 to 5, wherein

the ejection part includes an upstream ejection part disposed upstream in a flow direction of gas flowing

through the target region and a downstream ejection part disposed downstream in the flow direction of the gas in the target region, and

an ejection amount of the non-flammable gas from the downstream ejection part is larger than an ejection amount of the non-flammable gas from the upstream ejection part.

7. The auto-ignition prevention device according to any one of claims 1 to 6, wherein a flow rate of the non-flammable gas ejected from the ejection part is set in accordance with a property of the flammable gas.

8. The auto-ignition prevention device according to any one of claims 1 to 7, wherein a flow rate of the non-flammable gas ejected from the ejection part is set in accordance with a property of gas flowing through the target region.