

SPECIFICATION

TITLE OF THE INVENTION: MARINE DESULFURIZATION DEVICE

TECHNICAL FIELD

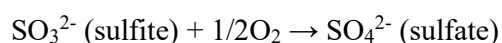
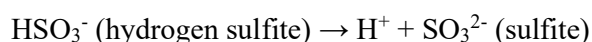
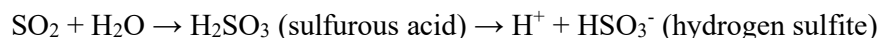
5 [0001] The present disclosure relates to a marine desulfurization device for desulfurizing exhaust gas discharged from an exhaust gas generating device mounted on a ship.

The present application claims priority based on Japanese Patent Application No. 2022-062644 filed on April 4, 2022, the entire content of which is incorporated herein by reference.

10 BACKGROUND ART

[0002] In seawater desulfurization, SO_x in exhaust gas is absorbed and removed by seawater through gas-liquid contact with seawater in an absorption tower. The majority of SO_x is SO₂, and SO₂ dissolves in water to form hydrogen sulfite and sulfite, which are oxidized to sulfate in seawater containing oxygen. The sulfate produced is present in large quantities
15 in seawater and has little impact on the marine environment.

(Reaction equation)



20 The formation of sulfite makes seawater acidic, but the alkalinity of seawater neutralizes this to some extent.

[0003] With the recent tightening of the exhaust gas regulations for ships, in the emission control area (ECA), it is required to use fuel oil containing 0.1% or less of sulfur, or to take an alternative measure that has an equivalent effect. Furthermore, from 2020, also in a normal
25 sea area, it is going to be required to use fuel oil containing 0.5% or less of sulfur, or to take an alternative measure that has an equivalent effect. Typically, super-size ships such as ultra large container ships (ULCS) have used a low-sulfate fuel oil which contains a small amount of sulfate to comply with such regulations. In future, a demand for provision of desulfurization

devices will increase also for these super-size ships.

[0004] Patent Document 1 discloses an emergency cooling device configured to supply emergency cooling water from an emergency tank which stores emergency cooling water to a spray pipe of an exhaust gas cooling device and to spray the emergency cooling water through a cooling water nozzle disposed in the spray pipe during an emergency where the absorption liquid cannot be sprayed in the absorption tower (when power is lost). This emergency cooling device cools the exhaust gas in an emergency by spraying the emergency cooling water, thus preventing the absorption tower from breaking down due to heat from the exhaust gas that has not been cooled and remains at a high temperature.

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Citation List

Patent Literature

[0005] Patent Document 1: JP2019-104481A

15 SUMMARY

Problems to be Solved

[0006] The emergency cooling device described in Patent Document 1 requires the installation of the emergency tank to store emergency cooling water, which causes the emergency tank to occupy part of the onboard space of a ship equipped with a flue gas desulfurizer. In addition, the installation of the emergency cooling device including the emergency tank in the flue gas desulfurizer may cause the flue gas desulfurizer to become larger and more expensive. It is thus desirable to provide a marine desulfurization device that can cool exhaust gas with cooling water in an emergency without an emergency tank dedicated to emergency cooling water.

20 [0007] In view of the above, an object of at least one embodiment of the present invention is to provide a marine desulfurization device that can spray cooling water in an emergency without an emergency tank dedicated to emergency cooling water.

Solution to the Problems

[0008] A marine desulfurization device according to at least one embodiment of the invention is a marine desulfurization device for desulfurizing exhaust gas discharged from an exhaust gas generating device mounted on a ship, including: an absorption tower having an interior space for desulfurizing the exhaust gas and having an exhaust gas inlet for introducing the exhaust gas into the interior space; a spraying device capable of spraying a cleaning liquid to the exhaust gas flowing in the interior space, the spraying device including a plurality of first spray pipes arranged in the interior space, a first header pipe connected to each of the plurality of first spray pipes, and a plurality of second spray pipes arranged in the interior space below the plurality of first spray pipes and the first header pipe; a cleaning liquid supply device including a cleaning liquid supply pump configured to pressurize the cleaning liquid, and a cleaning liquid supply pipe configured to supply the cleaning liquid pressurized by the cleaning liquid supply pump to the first header pipe; a first branch pipe connecting the cleaning liquid supply pipe to each of the plurality of second spray pipes; and an emergency backflow prevention valve configured to prevent backflow from the cleaning liquid supply pipe to the cleaning liquid supply pump when the cleaning liquid supply pump is stopped, the emergency backflow prevention valve being disposed between the cleaning liquid supply pump and a connection portion where the cleaning liquid supply pipe is connected to the first branch pipe.

Advantageous Effects

[0009] At least one embodiment of the present invention provides a marine desulfurization device that can spray cooling water in an emergency without an emergency tank dedicated to emergency cooling water.

BRIEF DESCRIPTION OF DRAWINGS

[0010] FIG. 1 is a schematic diagram of a marine desulfurization device according to an embodiment.

FIG. 2 is an explanatory diagram for describing a spraying device in the marine

desulfurization device according to an embodiment.

FIG. 3 is a schematic diagram of the marine desulfurization device according to an embodiment.

FIG. 4 is a schematic diagram of the marine desulfurization device according to an
5 embodiment.

DETAILED DESCRIPTION

[0011] Embodiments of the present invention will now be described in detail with reference to the accompanying drawings. It is intended, however, that unless particularly identified,
10 dimensions, materials, shapes, relative positions, and the like of components described in the embodiments shall be interpreted as illustrative only and not intended to limit the scope of the present invention.

[0012] (Marine desulfurization device)

FIG. 1 is a schematic diagram of a marine desulfurization device according to an
15 embodiment. The marine desulfurization device 1 is configured to desulfurize exhaust gas discharged from a combustion device (exhaust gas generating device) 11 such as engines and boilers. The marine desulfurization device 1 and the combustion device 11 are mounted on a ship. As shown in FIG. 1, the marine desulfurization device 1 includes an absorption tower 2 having an interior space 21 for desulfurizing exhaust gas, a spraying device 3 configured to
20 spray a cleaning liquid to the exhaust gas flowing in the interior space 21, and a cleaning liquid supply device 4 configured to supply the cleaning liquid to the spraying device 3.

[0013] As shown in FIG. 1, the marine desulfurization device 1 is designed to bring exhaust gas discharged from the exhaust gas generating device 11 into contact with a cleaning liquid (absorption liquid) so that sulfur oxides (e.g., sulfur dioxide) in the exhaust gas is absorbed by
25 the cleaning liquid to remove sulfur oxides from the exhaust gas. The marine desulfurization device 1 may use a cleaning liquid to which an alkaline component such as caustic soda is added. When caustic soda is used, sodium sulfate is a byproduct.

[0014] In the following description, when simply referring to “upstream”, it shall refer to

upstream along the direction of a main flow of fluid in a portion or area for which the direction is being described. Similarly, in the following description, when simply referring to “downstream”, it shall refer to downstream along the direction of a main flow of fluid in a portion or area for which the direction is being described.

5 [0015] (Absorption tower)

The absorption tower 2 has an exhaust gas inlet 22 for introducing exhaust gas into the interior space 21, and an exhaust gas outlet 23 for discharging the cleaned exhaust gas from the interior space 21.

[0016] In some embodiments, as shown in FIG. 1, the absorption tower 2 includes an
10 absorber body part 24 having a first interior space 21A through which the exhaust gas flows upward from below, and an exhaust gas introduction part 25 having a second interior space 21B through which the exhaust gas flows downward from above for introducing the exhaust gas from the exhaust gas inlet 22 to the first interior space 21A. The first interior space 21A and the second interior space 21B are both parts of the interior space 21. The absorber body part
15 24 is configured to internally define the first interior space 21A. The exhaust gas introduction part 25 is configured to internally define the second interior space 21B.

[0017] The first interior space 21A includes a first gas-liquid contact part 21C for bringing the exhaust gas into gas-liquid contact with the cleaning liquid, and a liquid reservoir 21D
20 disposed below the first gas-liquid contact part 21C for storing the cleaning liquid that has absorbed sulfur oxides (e.g., sulfur dioxide) from the exhaust gas in the first gas-liquid contact part 21C.

[0018] As shown in FIG. 1, the absorber body part 24 has a communication port 26 for introducing the exhaust gas from the second interior space 21B to the first interior space 21A. The communication port 26 is disposed below the first gas-liquid contact part 21C and above
25 the liquid reservoir 21D and connects the second interior space 21B to the first interior space 21A. In other words, the second interior space 21B communicates with the first interior space 21A (21E) below the first gas-liquid contact part 21C and above the liquid reservoir 21D through the communication port 26. The communication port 26 is disposed below the

exhaust gas outlet 23.

[0019] Each of the absorber body part 24 and the exhaust gas introduction part 25 is formed in a cylindrical shape extending along the vertical direction. The lower end of the exhaust gas introduction part 25 is connected to the absorber body part 24, and the exhaust gas inlet 22 is formed at the upper end of the exhaust gas introduction part 25. The exhaust gas outlet 23 is disposed above the first gas-liquid contact part 21C of the absorber body part 24. The exhaust gas outlet 23 communicates with the first interior space 21A (21F) above the first gas-liquid contact part 21C.

[0020] Exhaust gas from the exhaust gas generating device 11 is introduced into the second interior space 21B through the exhaust gas inlet 22. The exhaust gas that has flowed through the second interior space 21B from above to below is directed to the first interior space 21A (21E) through the communication port 26. The exhaust gas that has flowed through the first interior space 21A from below to above is scrubbed with the cleaning liquid when passing through the first gas-liquid contact part 21C to remove sulfur oxides in the exhaust gas. After being scrubbed with the cleaning liquid, the exhaust gas is discharged to the outside of the absorption tower 2 through the exhaust gas outlet 23 and is released into the atmosphere through a stack or the like.

[0021] (Spraying device)

As shown in FIG. 1, the spraying device 3 includes a plurality of first spray pipes 31 arranged in the interior space 21, a first header pipe 32 connected to each of the plurality of first spray pipes 31, and a plurality of second spray pipes 33 arranged in the interior space 21 below the plurality of first spray pipes 31 and the first header pipe 32. Each of the plurality of first spray pipes 31, first header pipe 32, and plurality of second spray pipes 33 extends along the horizontal direction.

[0022] In the illustrated embodiment, the plurality of first spray pipes 31 is arranged in the first interior space 21A. The first header pipe 32 is arranged outside the absorber body part 24 and the exhaust gas introduction part 25. Each of the plurality of first spray pipes 31 is connected to the first header pipe 32 at one end protruding outside the absorber body part 24.

The plurality of second spray pipes 33 is arranged in the second interior space 21B.

[0023] (Spray nozzle)

As shown in FIG. 1, the spraying device 3 further includes a plurality of first spray nozzles 34 disposed in each of the plurality of first spray pipes 31 for spraying the cleaning liquid, and
5 a plurality of second spray nozzles 35 disposed in each of the plurality of second spray pipes 33 for spraying the cleaning liquid.

[0024] In the illustrated embodiment, each of the plurality of first spray nozzles 34 is configured to inject the cleaning liquid upward. Each of the plurality of first spray nozzles 34 has at least one nozzle hole 341 that opens upward to inject the cleaning liquid upward through
10 the nozzle hole 341.

[0025] In the illustrated embodiment, each of the plurality of second spray nozzles 35 is configured to inject the cleaning liquid upward. Each of the plurality of second spray nozzles 35 has at least one nozzle hole 351 that opens upward to inject the cleaning liquid upward through the nozzle hole 351.

15 [0026] (Cleaning liquid supply device)

As shown in FIG. 1, the cleaning liquid supply device 4 includes a cleaning liquid supply pump 41 configured to pressurize the cleaning liquid, and a cleaning liquid supply pipe 42 configured to supply the cleaning liquid pressurized by the cleaning liquid supply pump 41 to the first header pipe 32. One end of the cleaning liquid supply pipe 42 is connected to the
20 cleaning liquid outlet of the cleaning liquid supply pump 41, and the other end of the cleaning liquid supply pipe 42 is connected to the first header pipe 32.

[0027] As shown in FIG. 1, the cleaning liquid supply device 4 further includes a cleaning liquid introduction pipe 44 for introducing the cleaning liquid from a cleaning liquid storage source 40 configured to store the cleaning liquid to the cleaning liquid supply pump 41. In
25 the illustrated embodiment, the cleaning liquid storage source 40 includes the liquid reservoir 21D. One end of the cleaning liquid introduction pipe 44 is connected to a cleaning liquid extraction port 241 formed in the absorber body part 24, which communicates with the liquid reservoir 21D, and the other end of the cleaning liquid introduction pipe 44 is connected to the

cleaning liquid inlet of the cleaning liquid supply pump 41.

[0028] By supplying power to the cleaning liquid supply pump 41 to drive the cleaning liquid supply pump 41, the cleaning liquid is directed from the cleaning liquid storage source 40 to the cleaning liquid supply pump 41 through the cleaning liquid introduction pipe 44 and is pressurized. The cleaning liquid pressurized at the cleaning liquid supply pump 41 is supplied to each of the plurality of first spray pipes 31 through the cleaning liquid supply pipe 42 and the first header pipe 32, and is sprayed through each of the plurality of first spray nozzles 34 to the exhaust gas that passes through the first gas-liquid contact part 21C. The cleaning liquid sprayed through each of the plurality of first spray nozzles 34 comes into contact with the exhaust gas and absorbs and removes sulfur oxides (e.g., sulfur dioxide) contained in the exhaust gas. The cleaning liquid sprayed through each of the plurality of first spray nozzles 34 to absorb and remove sulfur oxides in the exhaust gas falls and is stored in the liquid reservoir 21D.

[0029] As shown in FIG. 1, the cleaning liquid supply device 4 may further include a cleaning liquid supply line 45 configured to supply the cleaning liquid to the liquid reservoir 21D. The cleaning liquid supply line 45 includes a cleaning liquid tank 451 disposed outside the absorption tower 2 and configured to store the cleaning liquid, a cleaning liquid replenishment pipe 452 connected at one end to the cleaning liquid tank 451 and at the other end to a cleaning liquid supply port 242 formed in the absorber body part 24, which communicates with the first interior space 21A above the liquid reservoir 21D, and a cleaning liquid replenishment valve 453 disposed in the cleaning liquid replenishment pipe 452. The cleaning liquid replenishment valve 453 has a valve body for opening and closing the cleaning liquid replenishment pipe 452 and is configured to adjust the amount of cleaning liquid supplied into the liquid reservoir 21D via the cleaning liquid replenishment valve 453 by changing the opening degree of the valve body.

[0030] The absorption tower 2 is configured to circulate the cleaning liquid through the cleaning liquid introduction pipe 44, the cleaning liquid supply pipe 42, the first header pipe 32, and the first spray pipes 31, in that order. Since the cleaning liquid stored in the liquid

reservoir 21D is repeatedly used for cleaning the exhaust gas, sodium sulfate gradually accumulates. When sodium sulfate accumulates above a certain concentration, it begins to precipitate. Therefore, the cleaning liquid supply device 4 may further include a cleaning liquid discharge line 47 configured to extract the cleaning liquid containing sodium sulfate from the cleaning liquid supply pipe 42 and send it to a wastewater treatment facility 46, as shown in FIG. 1.

[0031] (Packing layer)

As shown in FIG. 1, the absorber body part 24 may further include a packing layer 27 disposed below the first spray pipes 31 and above the communication port 26 in the first interior space 21A. The packing layer 27 has a packing material 271 to bring the cleaning liquid, which is sprayed through each of the plurality of first spray nozzles 34 and passes from above to below, into contact with the exhaust gas, which passes from below to above. The packing layer 27 (packing material 271) is installed along the horizontal direction in the first interior space 21A to increase the contact area (gas-liquid contact area) between the cleaning liquid and the exhaust gas. The cleaning liquid sprayed through each of the plurality of first spray nozzles 34 falls across the surface of the packing material 271, so that water droplets adhere to the surface of the packing material 271. The exhaust gas flows through the gap formed in the packing material 271 upward while impinging on the surface of the packing material 271. The exhaust gas is cleaned by the water droplets which adhere to the surface of the packing material 271 as it impinges on the surface.

[0032] (Mist eliminator)

As shown in FIG. 1, the absorber body part 24 may further include a mist eliminator 28 configured to remove water content from the exhaust gas that has been cleaned with the cleaning liquid. The mist eliminator 28 is disposed at the exhaust gas outlet 23 or in the first interior space 21A (21F) above the first gas-liquid contact part 21C.

[0033] (First branch pipe, Emergency backflow prevention valve)

As shown in FIG. 1, the marine desulfurization device 1 according to some embodiments is provided with the above-described absorption tower 2, the above-described spraying device

3, the above-described cleaning liquid supply device 4, a first branch pipe 51 connecting the cleaning liquid supply pipe 42 to each of the plurality of second spray pipes 33, and an emergency backflow prevention valve 43 configured to prevent backflow from the cleaning liquid supply pipe 42 to the cleaning liquid supply pump 41 when the cleaning liquid supply pump 41 is stopped. The emergency backflow prevention valve 43 is disposed between the cleaning liquid supply pump 41 and a connection portion P1 where the cleaning liquid supply pipe 42 is connected to the first branch pipe 51. In this disclosure, “when the cleaning liquid supply pump 41 is stopped” means an emergency state, such as when the supply of electric power to the equipment of the marine desulfurization device 1, such as the cleaning liquid supply pump 41, is suddenly stopped. In this disclosure, “when the cleaning liquid supply pump 41 is operating” means a steady state where the supply of electric power to the equipment of the marine desulfurization device 1, such as the cleaning liquid supply pump 41, is stable.

[0034] The first branch pipe 51 is connected at one end to the cleaning liquid supply pipe 42 and at the other ends to each of the plurality of second spray pipes 33. The emergency backflow prevention valve 43 may be a check valve configured such that the valve body prevents backflow due to back pressure of the cleaning liquid, or it may be a solenoid valve configured to close when the power is lost (de-energized). The emergency backflow prevention valve 43 may be configured to be able to prevent backflow from the cleaning liquid supply pipe 42 to the cleaning liquid supply pump 41 even when the cleaning liquid supply pump 41 is operating.

[0035] With the above configuration, when the cleaning liquid supply pump 41 is operating, the cleaning liquid pressurized by the cleaning liquid supply pump 41 is supplied to the plurality of first spray pipes 31 through the cleaning liquid supply pipe 42 and the first header pipe 32. Thus, the cleaning liquid is stored in the first header pipe 32. When the cleaning liquid supply pump 41 is stopped, the emergency backflow prevention valve 43 prevents backflow from the cleaning liquid supply pipe 42 to the cleaning liquid supply pump 41, so the cleaning liquid stored in the first header pipe 32 flows down to the plurality of second spray pipes 33 arranged below the first header pipe 32 and is sprayed as emergency cooling water from the plurality of

second spray pipes 33 (plurality of second spray nozzles 35) into the interior space 21 of the absorption tower 2. In other words, with the above configuration, the cleaning liquid stored in the first header pipe 32 can be used as emergency cooling water. Thus, the marine desulfurization device 1 can spray the cleaning liquid (cooling water) from the second spray pipes 33 (second spray nozzles 35) in an emergency without an emergency tank dedicated to emergency cooling water.

[0036] In some embodiments, as shown in FIG. 1, each of the plurality of first spray nozzles 34 is configured to inject the cleaning liquid upward. Each of the plurality of first spray nozzles 34 has at least one nozzle hole 341 that opens upward to inject the cleaning liquid upward through the nozzle hole 341.

[0037] With the above configuration, when the cleaning liquid supply pump 41 is operating, the cleaning liquid pressurized by the cleaning liquid supply pump 41 is supplied to the plurality of first spray pipes 31 and stored in the plurality of first spray pipes 31. The plurality of first spray nozzles 34 is configured to inject the cleaning liquid upward. Specifically, each of the plurality of nozzle holes 341 opens upward. When the cleaning liquid supply pump 41 is stopped, the cleaning liquid stored in the plurality of first spray pipes 31 does not flow out of the nozzle holes 341 of the plurality of first spray nozzles 34. Therefore, when the cleaning liquid supply pump 41 is stopped, the cleaning liquid stored in the plurality of first spray pipes 31 flows down to the plurality of second spray pipes 33 and is sprayed as emergency cooling water from the plurality of second spray pipes 33 into the interior space 21 of the absorption tower 2. In other words, with the above configuration, the cleaning liquid stored in the plurality of first spray pipes 31 can be used as emergency cooling water.

[0038] In some embodiments, as shown in FIG. 1, the above-described absorption tower 2 includes the above-described absorber body part 24 having the first interior space 21A and the above-described exhaust gas introduction part 25 having the second interior space 21B. The plurality of first spray pipes 31 is arranged in the first interior space 21A, and the plurality of second spray pipes 33 is arranged in the second interior space 21B.

[0039] With the above configuration, when the cleaning liquid supply pump 41 is stopped,

the cleaning liquid stored in the first header pipe 32, etc., is sprayed as emergency cooling water from the plurality of second spray pipes 33 into the second interior space 21B. Spraying the cleaning liquid to the second interior space 21B can cool the exhaust gas flowing through the second interior space 21B before it is introduced into the first interior space 21A. This prevents damage to devices installed in the first interior space 21A due to heat from the exhaust gas.

[0040] For example, the absorber body part 24 may have a resin sheet attached to its inner wall facing the first interior space 21A to improve the corrosion resistance of the inner wall. The resin sheet can be prevented from being damaged by heat from the exhaust gas. Further, the packing material 271 placed in the packing layer 27 and the mist eliminator 28 may contain a resin material. The resin material can be prevented from being damaged by heat from the exhaust gas.

[0041] In the above-described embodiments, as shown in FIG. 1, the above-described absorption tower 2 includes the above-described absorber body part 24 having the first interior space 21A and the above-described exhaust gas introduction part 25 having the second interior space 21B. The spraying device 3 includes a plurality of second spray nozzles 35 disposed in each of the plurality of second spray pipes 33. Each of the plurality of second spray pipes 33 is arranged in the second interior space 21B, and the plurality of second spray nozzles 35 includes a plurality of second upward spray nozzles 35A configured to inject the cleaning liquid upward.

[0042] With the above configuration, when the cleaning liquid supply pump 41 is stopped, the second upward spray nozzles 35A can cool the exhaust gas by injecting the cleaning liquid upward to the exhaust gas flowing downward from above in the second interior space 21B. This prevents damage due to heat from the exhaust gas that passes around the second upward spray nozzles 35A and is introduced into the first interior space 21A.

[0043] In some embodiments, as shown in FIG. 1, the above-described marine desulfurization device 1 is further provided with a flow regulating valve 52 disposed in the first branch pipe 51. The flow regulating valve 52 is configured to open at a predetermined

opening degree when the cleaning liquid supply pump 41 is operating. The flow regulating valve 52 is configured to open at respective predetermined opening degrees when the power is supplied and when the power is lost (de-energized).

[0044] The second interior space 21B includes a second gas-liquid contact part 21G for bringing the exhaust gas into gas-liquid contact with the cleaning liquid. The second gas-liquid contact part 21G is disposed above the plurality of second spray pipes 33. The second gas-liquid contact part 21G is part of the second interior space 21B.

[0045] When the cleaning liquid supply pump 41 is operating, part of the cleaning liquid pressurized at the cleaning liquid supply pump 41 is supplied to each of the plurality of second spray pipes 33 through a portion of the cleaning liquid supply pipe 42 between the cleaning liquid supply pump 41 and the connection portion P1 to the first branch pipe 51 and through the first branch pipe 51, and is sprayed through each of the plurality of second spray nozzles 35 to the exhaust gas that passes through the second gas-liquid contact part 21G. The cleaning liquid sprayed through each of the plurality of second spray nozzles 35 comes into contact with the exhaust gas and absorbs and removes sulfur oxides (e.g., sulfur dioxide) contained in the exhaust gas and also lowers the temperature of the exhaust gas. The cleaning liquid sprayed through each of the plurality of second spray nozzles 35 to absorb and remove sulfur oxides in the exhaust gas falls and is stored in the liquid reservoir 21D.

[0046] With the above configuration, the flow regulating valve 52 in the first branch pipe 51 is opened at a predetermined opening degree when the cleaning liquid supply pump 41 is operating, so that the cleaning liquid can be sprayed from the second spray pipes 33 into the interior space 21 not only when the cleaning liquid supply pump 41 is stopped, but also when the cleaning liquid supply pump 41 is operating. In other words, the second spray pipes 33 can spray the cleaning liquid into the interior space 21 during operation of the cleaning liquid supply pump 41 to desulfurize the exhaust gas flowing in the interior space 21 and lower the temperature of the exhaust gas. By using the second spray pipes 33 during both operation and shutdown of the cleaning liquid supply pump 41, the structural complexity of the marine desulfurization device 1 can be reduced.

[0047] In some embodiments, the above-described flow regulating valve 52 is configured to open at a larger opening degree when the cleaning liquid supply pump 41 is stopped than when the cleaning liquid supply pump 41 is operating. The flow regulating valve 52 is configured to open at a larger opening degree when the power is lost (de-energized) than when the power is supplied. The flow regulating valve 52 may be an electric valve driven by an electric motor or a solenoid valve driven by passing current through an electromagnet.

[0048] With the above configuration, the flow regulating valve 52 in the first branch pipe 51 is opened at a larger opening degree when the cleaning liquid supply pump 41 is stopped than when the cleaning liquid supply pump 41 is operating, so that the cleaning liquid stored in the first header pipe 32 can quickly flow down to the plurality of second spray pipes 33 through the first branch pipe 51. This allows the necessary flow rate of cleaning liquid (cooling water) to be supplied to the second spray pipes 33 for spraying the cleaning liquid from the second spray pipes 33 in an emergency.

[0049] FIG. 2 is an explanatory diagram for describing a spraying device in the marine desulfurization device according to an embodiment. In some embodiments, each of the absorber body part 24 and the exhaust gas introduction part 25 is formed in a rectangular shape in a cross-section perpendicular to the vertical direction, as shown in FIG. 2. In a cross-section perpendicular to the vertical direction, the absorber body part 24 includes a first wall portion 61 extending along a first direction, a second wall portion 62 extending along the first direction at a distance from the first wall portion 61 in a second direction perpendicular to the first direction, a third wall portion 63 extending along the second direction and connecting one end of the first wall portion 61 to one end of the second wall portion 62, and a fourth wall portion 64 extending along the second direction at a distance from the third wall portion 63 in the first direction and connecting the other end of the first wall portion 61 to the other end of the second wall portion 62. The first interior space 21A is formed between the first wall portion 61 and the second wall portion 62 in the second direction and between the third wall portion 63 and the fourth wall portion 64 in the first direction.

[0050] As shown in FIG. 2, the first header pipe 32 is arranged along one of the four wall

portions 61, 62, 63, and 64 of the absorber body part 24, which has a rectangular cross-section perpendicular to the vertical direction. Each of the plurality of first spray pipes 31 extends along a direction intersecting (in the illustrated example, perpendicular to) the extension direction of the first header pipe 32 in top view. Each of the plurality of first spray pipes 31 may extend along the extension direction of the first header pipe 32 in top view.

[0051] In the embodiment shown in FIG. 2, the first header pipe 32 is arranged outward of the second wall portion 62 along the second wall portion 62, so it extends along the first direction. Each of the plurality of first spray pipes 31 extends along the second direction and is spaced apart from each other in the first direction in top view. Each of the plurality of second spray pipes 33 extends along the first direction and is spaced apart from each other in the second direction in top view. In this case, the lengthening of the first branch pipe 51 and piping losses associated with the lengthening can be suppressed. In other embodiments, the first header pipe 32 may be arranged along the third wall portion 63 or the fourth wall portion 64.

[0052] The first branch pipe 51 is disposed outside the absorber body part 24 and the exhaust gas introduction part 25. The first branch pipe 51 may include a second header pipe 51A at the other end opposite the one connected to the cleaning liquid supply pipe 42 and a conduit 51B connecting the cleaning liquid supply pipe 42 to the second header pipe 51A. The flow regulating valve 52 is provided on the conduit 51B.

[0053] As shown in FIG. 2, the second header pipe 51A is arranged along one of the four wall portions of the exhaust gas introduction part 25, which has a rectangular cross-section perpendicular to the vertical direction. In the embodiment shown in FIG. 2, the second header pipe 51A is arranged along the wall portion that extends along the second direction, so it extends along the second direction. Each of the plurality of second spray pipes 33 is connected to the second header pipe 51A at one end protruding outside the exhaust gas introduction part 25. Each of the first header pipe 32 and the second header pipe 51A has a larger inner diameter than each of the plurality of first spray pipes 31 and the plurality of second spray pipes 33 in order to provide a larger storage capacity for the cleaning liquid.

[0054] (Second branch pipe, Emergency on-off valve)

FIG. 3 is a schematic diagram of the marine desulfurization device according to an embodiment. In some embodiments, as shown in FIG. 3, the marine desulfurization device 1 is further provided with a second branch pipe 53 connecting the cleaning liquid supply pipe 42 to each of the plurality of second spray pipes 33, and an emergency on-off valve 54 disposed in the second branch pipe 53. The emergency on-off valve 54 is configured to close when the cleaning liquid supply pump 41 is operating and to open when the cleaning liquid supply pump 41 is stopped. Each of the first branch pipe 51 and the second branch pipe 53 has its uppermost portion located below the first header pipe 32.

[0055] The emergency on-off valve 54 is configured to open when the power is supplied and to open at a predetermined opening degree when the power is lost (de-energized). The emergency on-off valve 54 may be an electric valve driven by an electric motor or a solenoid valve driven by passing current through an electromagnet.

[0056] In the illustrated embodiment, one end of the second branch pipe 53 is connected to the cleaning liquid supply pipe 42 between the first header pipe 32 and the connection portion P1 where the cleaning liquid supply pipe 42 is connected to the first branch pipe 51. The connection portion where the cleaning liquid supply pipe 42 is connected to the second branch pipe 53 is designated as P2. The other end of the second branch pipe 53 is connected to the first branch pipe 51 (conduit 51B) between the flow regulating valve 52 and the second spray pipes 33 (second header pipe 51A). However, one end of the second branch pipe 53 may be connected to the cleaning liquid supply pipe 42 between the cleaning liquid supply pump 41 and the connection portion P1 where the cleaning liquid supply pipe 42 is connected to the first branch pipe 51, or may be connected to the first branch pipe 51 (conduit 51B) between the flow regulating valve 52 and the end (connection portion P1) connected to the cleaning liquid supply pipe 42.

[0057] With the above configuration, the emergency on-off valve 54 in the second branch pipe 53 is opened when the cleaning liquid supply pump 41 is stopped, so that the cleaning liquid stored in the first header pipe 32 can quickly flow down to the plurality of second spray

pipes 33 through the first branch pipe 51 and the second branch pipe 53. This allows the necessary flow rate of cleaning liquid (cooling water) to be supplied to the second spray pipes 33 for spraying the cleaning liquid from the second spray pipes 33 in an emergency. The flow regulating valve 52 may be configured to open when the cleaning liquid supply pump 41 is stopped or may be configured to close.

[0058] FIG. 4 is a schematic diagram of the marine desulfurization device according to an embodiment. The absorption tower 2 of the above-described embodiments includes, as shown in FIGs. 1 to 3, the above-described absorber body part 24 having the first interior space 21A and the above-described exhaust gas introduction part 25 having the second interior space 21B, but the present disclosure is also applicable to an absorption tower 2 that does not include the exhaust gas introduction part 25, as shown in FIG. 4.

[0059] As shown in FIG. 4, the marine desulfurization device 1 is provided with the absorption tower 2 including the above-described absorber body part 24 having the first interior space 21A, the above-described spraying device 3, the above-described cleaning liquid supply device 4, the above-described first branch pipe 51, and the above-described emergency backflow prevention valve 43. As shown in FIG. 4, the marine desulfurization device 1 may be further provided with the above-described flow regulating valve 52, the above-described second branch pipe 53, and the above-described emergency on-off valve 54. The absorption tower 2 has an exhaust gas inlet 22 at the position where the communication port 26 is formed in the first wall portion 61.

[0060] In some embodiments, as shown in FIG. 4, the plurality of first spray pipes 31 and the plurality of second spray pipes 33 are arranged in the first interior space 21A. In the illustrated embodiment, the plurality of second spray pipes 33 is disposed below the plurality of first spray pipes 31 and the packing layer 27 and above the exhaust gas inlet 22 and the liquid reservoir 21D.

[0061] With the above configuration, when the cleaning liquid supply pump 41 is stopped, the cleaning liquid stored in the first header pipe 32, etc., is sprayed as emergency cooling water from the plurality of second spray pipes 33 into the first interior space 21A below the plurality

of first spray pipes 31. The temperature of the exhaust gas is lowered by spraying the cleaning liquid (cooling water), thereby preventing damage to devices installed above the plurality of second spray pipes 33 in the first interior space 21A due to heat from the exhaust gas.

[0062] In some embodiments, as shown in FIG. 4, the absorber body part 24 includes a packing layer 27 disposed below the first spray pipes 31 and above the second spray pipes 33 in the first interior space 21A. The plurality of second spray nozzles 35 includes a plurality of second upward spray nozzles 35A configured to inject the cleaning liquid upward and a plurality of second downward spray nozzles 35B disposed in proximity to the exhaust gas inlet 22 and configured to inject the cleaning liquid downward.

[0063] The position in proximity to the exhaust gas inlet 22 means that it is closer to the first wall portion 61 than the second wall portion 62 in the second direction (left-right direction in FIG. 4). For example, when each of the plurality of second spray pipes 33 is arranged along the second direction, the second spray nozzle 35 closest to the first wall portion 61 in each second spray pipe 33 may be the second downward spray nozzle 35B and the other second spray nozzles 35 may be the second upward spray nozzles 35A. When each the plurality of second spray pipes 33 is arranged along the first direction (vertical direction on the paper in FIG. 4), the plurality of second spray nozzles 35 in the second spray pipe 33 closest to the first wall portion 61 may be the second downward spray nozzles 35B, and the plurality of second spray nozzles 35 in the other second spray pipes 33 may be the second upward spray nozzles 35A.

[0064] With the above configuration, each of the plurality of second downward spray nozzles 35B disposed in proximity to the exhaust gas inlet 22 injects the cleaning liquid downward, thereby preventing a decrease in desulfurization performance due to exhaust gas blow-through around the wall near the exhaust gas inlet 22 in the first interior space 21A. Further, the cleaning liquid sprayed through the second downward spray nozzles 35B can quickly cool the exhaust gas led into the first interior space 21A through the exhaust gas inlet 22. Each of the plurality of second upward spray nozzles 35A injects the cleaning liquid upward to cool the packing layer 27, thereby preventing damage to the packing layer 27 due to

heat from the exhaust gas that passes through the packing layer 27.

[0065] In the present specification, an expression of relative or absolute arrangement such as “in a direction”, “along a direction”, “parallel”, “orthogonal”, “centered”, “concentric” and “coaxial” shall not be construed as indicating only the arrangement in a strict literal sense, but also includes a state where the arrangement is relatively displaced by a tolerance, or by an angle or a distance whereby it is possible to achieve the same function.

For instance, an expression of an equal state such as “same” “equal” and “uniform” shall not be construed as indicating only the state in which the feature is strictly equal, but also includes a state in which there is a tolerance or a difference that can still achieve the same function.

Further, an expression of a shape such as a rectangular shape or a cylindrical shape shall not be construed as only the geometrically strict shape, but also includes a shape with unevenness or chamfered corners within the range in which the same effect can be achieved.

On the other hand, an expression such as “comprise”, “include”, and “have” are not intended to be exclusive of other components.

[0066] The present disclosure is not limited to the embodiments described above, but includes modifications to the embodiments described above, and embodiments composed of combinations of those embodiments.

For example, in the embodiment of FIG. 4, the plurality of second spray nozzles 35 includes the plurality of second upward spray nozzles 35A, and the plurality of second downward spray nozzles 35B disposed in proximity to the exhaust gas inlet 22, but the plurality of second upward spray nozzles 35A may be replaced with downward spray nozzles, so that the plurality of second spray nozzles 35 may all be configured with downward spray nozzles. When the plurality of second spray nozzles 35 is all downward spray nozzles, it is easier to ensure cooling time for the exhaust gas introduced through the exhaust gas inlet 22.

For example, in the embodiments of FIGs. 3 and 4, in order to supply the cleaning liquid (cooling water) to the second spray pipes 33 at a flow rate necessary for spraying the cleaning liquid from the second spray pipes 33 in an emergency, the device is provided with the first

branch pipe (and the flow regulating valve 52 disposed in the first branch pipe) and the second branch pipe 53 (and the emergency on-off valve 54 disposed in the second branch pipe 53) so that the cleaning liquid stored in the first header pipe 32 flows down to the second spray pipes 33 through the first branch pipe 51 and the second branch pipe 53, but the second branch pipe 53 and the emergency on-off valve 54 can be omitted by replacing the flow regulating valve 52 in the first branch pipe with an emergency on-off valve configured to open when the power is lost (de-energized) so that the necessary flow rate of cleaning liquid (cooling water) can be supplied to the second spray pipes 33 through the first branch pipe in an emergency. In this case, the first branch pipe 51 and the emergency on-off valve in the first branch pipe are dedicated equipment to cause the cleaning liquid (cooling water) stored in the first header pipe 32 to flow down to the second spray pipes 33 in an emergency.

[0067] The contents described in the above embodiments would be understood as follows, for instance.

[0068] 1) A marine desulfurization device (1) according to at least one embodiment of the present disclosure is a marine desulfurization device (1) for desulfurizing exhaust gas discharged from an exhaust gas generating device (11) mounted on a ship, including: an absorption tower (2) having an interior space (21) for desulfurizing the exhaust gas and having an exhaust gas inlet (22) for introducing the exhaust gas into the interior space (21); a spraying device (3) capable of spraying a cleaning liquid to the exhaust gas flowing in the interior space (21), the spraying device (3) including a plurality of first spray pipes (31) arranged in the interior space (21), a first header pipe (32) connected to each of the plurality of first spray pipes (31), and a plurality of second spray pipes (33) arranged in the interior space (21) below the plurality of first spray pipes (31) and the first header pipe (32); a cleaning liquid supply device (4) including a cleaning liquid supply pump (41) configured to pressurize the cleaning liquid, and a cleaning liquid supply pipe (42) configured to supply the cleaning liquid pressurized by the cleaning liquid supply pump (41) to the first header pipe (32); a first branch pipe (51) connecting the cleaning liquid supply pipe (42) to each of the plurality of second spray pipes (33); and an emergency backflow prevention valve (43) configured to prevent backflow from

the cleaning liquid supply pipe (42) to the cleaning liquid supply pump (41) when the cleaning liquid supply pump (41) is stopped, the emergency backflow prevention valve (43) being disposed between the cleaning liquid supply pump (41) and a connection portion (P1) where the cleaning liquid supply pipe (42) is connected to the first branch pipe (51).

5 [0069] With the above configuration 1), when the cleaning liquid supply pump (41) is operating, the cleaning liquid pressurized by the cleaning liquid supply pump (41) is supplied to the plurality of first spray pipes (31) through the cleaning liquid supply pipe (42) and the first header pipe (32). Thus, the cleaning liquid is stored in the first header pipe (32). When the cleaning liquid supply pump (41) is stopped, the emergency backflow prevention valve (43)
10 prevents backflow from the cleaning liquid supply pipe (42) to the cleaning liquid supply pump (41), so the cleaning liquid stored in the first header pipe (32) flows down to the plurality of second spray pipes (33) arranged below the first header pipe (32) and is sprayed as emergency cooling water from the second water pipes (33) into the interior space (21) of the absorption tower (2). In other words, with the above configuration 1), the cleaning liquid stored in the
15 first header pipe (32) can be used as emergency cooling water. Thus, the marine desulfurization device (1) can spray the cleaning liquid (cooling water) from the second spray pipes (33) in an emergency without an emergency tank dedicated to emergency cooling water.

[0070] 2) In some embodiments, the marine desulfurization device (1) described in 1) is further provided with a flow regulating valve (52) disposed in the first branch pipe (51) and
20 configured to open at a predetermined opening degree when the cleaning liquid supply pump (41) is operating.

[0071] With the above configuration 2), the flow regulating valve (52) in the first branch pipe (51) is opened at a predetermined opening degree when the cleaning liquid supply pump (41) is operating, so that the cleaning liquid can be sprayed from the second spray pipes (33)
25 into the interior space (21) not only when the cleaning liquid supply pump (41) is stopped, but also when the cleaning liquid supply pump (41) is operating. In other words, the second spray pipes (33) can spray the cleaning liquid into the interior space (21) during operation of the cleaning liquid supply pump (41) to desulfurize the exhaust gas flowing in the interior space

(21) and lower the temperature of the exhaust gas.

[0072] 3) In some embodiments, in the marine desulfurization device (1) described in 2), the flow regulating valve (52) is configured to open at a larger opening degree when the cleaning liquid supply pump (41) is stopped than when the cleaning liquid supply pump (41) is operating.

[0073] With the above configuration 3), the flow regulating valve (52) in the first branch pipe (51) is opened at a larger opening degree when the cleaning liquid supply pump (41) is stopped than when the cleaning liquid supply pump (41) is operating, so that the cleaning liquid stored in the first header pipe (32) can quickly flow down to the plurality of second spray pipes (33) through the first branch pipe (51). This allows the necessary flow rate of cleaning liquid to be supplied to the second spray pipes (33) for spraying the cleaning liquid from the second spray pipes (33) in an emergency.

[0074] 4) In some embodiments, the marine desulfurization device (1) described in 2) is further provided with: a second branch pipe (53) connecting the cleaning liquid supply pipe (41) to each of the plurality of second spray pipes (33); and an emergency on-off valve (54) disposed in the second branch pipe (53) and configured to close when the cleaning liquid supply pump (41) is operating and to open when the cleaning liquid supply pump (41) is stopped.

[0075] With the above configuration 4), the emergency on-off valve (54) in the second branch pipe (53) is opened when the cleaning liquid supply pump (41) is stopped, so that the cleaning liquid stored in the first header pipe (32) can quickly flow down to the plurality of second spray pipes (33) through the first branch pipe (51) and the second branch pipe (53). This allows the necessary flow rate of cleaning liquid to be supplied to the second spray pipes (33) for spraying the cleaning liquid from the second spray pipes (33) in an emergency.

[0076] 5) In some embodiments, in the marine desulfurization device (1) described in any one of 1) to 4), the spraying device (3) further includes a plurality of first spray nozzles (34) disposed in each of the plurality of first spray pipes (31) and configured to inject the cleaning liquid upward.

[0077] With the above configuration 5), when the cleaning liquid supply pump (41) is

operating, the cleaning liquid pressurized by the cleaning liquid supply pump (41) is supplied to the plurality of first spray pipes (31) and stored in the plurality of first spray pipes (31). Since the plurality of first spray nozzles (34) is configured to inject the cleaning liquid upward, when the cleaning liquid supply pump (41) is stopped, the cleaning liquid stored in the plurality of first spray pipes (31) does not flow out of the plurality of first spray nozzles (34). Therefore, when the cleaning liquid supply pump (41) is stopped, the cleaning liquid stored in the plurality of first spray pipes (31) flows down to the plurality of second spray pipes (33) and is sprayed as emergency cooling water from the plurality of second spray pipes (33) into the interior space (21) of the absorption tower (2). In other words, with the above configuration 5), the cleaning liquid stored in the plurality of first spray pipes (31) can be used as emergency cooling water.

[0078] 6) In some embodiments, in the marine desulfurization device (1) described in any one of 1) to 5), the absorption tower (2) includes: an absorber body part (24) having a first interior space (21A) through which the exhaust gas flows upward from below, the first interior space (21A) being part of the interior space (21); and an exhaust gas introduction part (25) having a second interior space (21B) through which the exhaust gas flows downward from above for introducing the exhaust gas from the exhaust gas inlet (22) to the first interior space (21A), the second interior space (21B) being part of the interior space (21). The plurality of first spray pipes (31) is arranged in the first interior space (21A), and the plurality of second spray pipes (33) is arranged in the second interior space (21B).

[0079] With the above configuration 6), when the cleaning liquid supply pump (41) is stopped, the cleaning liquid stored in the first header pipe (32), etc., is sprayed as emergency cooling water from the plurality of second spray pipes (33) into the second interior space (21B). Spraying the cleaning liquid to the second interior space (21B) can cool the exhaust gas flowing through the second interior space (21B) before it is introduced into the first interior space (21A). This prevents damage to devices installed in the first interior space (21A) due to heat from the exhaust gas.

[0080] 7) In some embodiments, in the marine desulfurization device (1) described in 6), the spraying device (3) further includes a plurality of second spray nozzles (35) disposed in

each of the plurality of second spray pipes (33). The plurality of second spray nozzles (35) includes a plurality of second upward spray nozzles (35A) configured to inject the cleaning liquid upward.

[0081] With the above configuration 7), when the cleaning liquid supply pump (41) is stopped, the second upward spray nozzles (35A) can cool the exhaust gas by injecting the cleaning liquid upward to the exhaust gas flowing downward from above in the second interior space (21B). This prevents damage due to heat from the exhaust gas that passes around the second upward spray nozzles (35A) and is introduced into the first interior space (21A).

[0082] 8) In some embodiments, in the marine desulfurization device (1) described in any one of 1) to 5), the absorption tower (2) includes an absorber body part (24) having a first interior space (21A) through which the exhaust gas flows upward from below, the first interior space (21A) being part of the interior space (21). The plurality of first spray pipes (31) and the plurality of second spray pipes (32) are arranged in the first interior space (21A).

[0083] With the above configuration 8), when the cleaning liquid supply pump (41) is stopped, the cleaning liquid stored in the first header pipe (32), etc., is sprayed as emergency cooling water from the plurality of second spray pipes (33) into the first interior space (21A) below the plurality of first spray pipes (31). The temperature of the exhaust gas is lowered by spraying the cleaning liquid (cooling water), thereby preventing damage to devices installed above the plurality of second spray pipes (33) in the first interior space (21A) due to heat from the exhaust gas.

[0084] 9) In some embodiments, in the marine desulfurization device (1) described in 8), the absorber body part (24) includes a packing layer (27) disposed below the first spray pipes (31) and above the second spray pipes (33) in the first interior space (21A). The spraying device (3) further includes a plurality of second spray nozzles (35) disposed in each of the plurality of second spray pipes (33). The plurality of second spray nozzles (35) includes a plurality of second upward spray nozzles (35A) configured to inject the cleaning liquid upward and a plurality of second downward spray nozzles (35B) disposed in proximity to the exhaust gas inlet (22) and configured to inject the cleaning liquid downward.

[0085] With the above configuration 9), each of the plurality of second downward spray nozzles (35B) disposed in proximity to the exhaust gas inlet (22) injects the cleaning liquid downward, thereby preventing a decrease in desulfurization performance due to exhaust gas blow-through around the wall near the exhaust gas inlet (22) in the first interior space (21A).

5 Further, the cleaning liquid sprayed through the second downward spray nozzles (35B) can quickly cool the exhaust gas led into the first interior space (21A) through the exhaust gas inlet (22). Each of the plurality of second upward spray nozzles (35A) injects the cleaning liquid upward to cool the packing layer (27), thereby preventing damage to the packing layer 27 due to heat from exhaust gas passing through the packing layer (27).

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Reference Signs List

[0086]

1	Marine desulfurization device
2	Absorption tower
15 3	Spraying device
4	Cleaning liquid supply device
11	Exhaust gas generating device
21	Interior space
21A	First interior space
20 21B	Second interior space
21C	First gas-liquid contact part
21D	Liquid reservoir
21G	Second gas-liquid contact part
22	Exhaust gas inlet
25 23	Exhaust gas outlet
24	Absorber body part
25	Exhaust gas introduction part
26	Communication port

	27	Packing layer
	28	Mist eliminator
	31	First spray pipe
	32	First header pipe
5	33	Second spray pipe
	34	First spray nozzle
	35	Second spray nozzle
	40	Storage source
	41	Cleaning liquid supply pump
10	42	Cleaning liquid supply pipe
	43	Emergency backflow prevention valve
	44	Cleaning liquid introduction pipe
	45	Cleaning liquid supply line
	46	Wastewater treatment facility
15	47	Cleaning liquid discharge line
	51	First branch pipe
	51A	Second header pipe
	51B	Conduit
	52	Flow regulating valve
20	53	Second branch pipe
	54	Emergency on-off valve
	61	First wall portion
	62	Second wall portion
	63	Third wall portion
25	64	Fourth wall portion

CLAIMS

[Claim 1] A marine desulfurization device for desulfurizing exhaust gas discharged from an exhaust gas generating device mounted on a ship, comprising:

5 an absorption tower having an interior space for desulfurizing the exhaust gas and having an exhaust gas inlet for introducing the exhaust gas into the interior space;

 a spraying device capable of spraying a cleaning liquid to the exhaust gas flowing in the interior space, the spraying device including a plurality of first spray pipes arranged in the interior space, a first header pipe connected to each of the plurality of first spray pipes, and a
10 plurality of second spray pipes arranged in the interior space below the plurality of first spray pipes and the first header pipe;

 a cleaning liquid supply device including a cleaning liquid supply pump configured to pressurize the cleaning liquid, and a cleaning liquid supply pipe configured to supply the cleaning liquid pressurized by the cleaning liquid supply pump to the first header pipe;

15 a first branch pipe connecting the cleaning liquid supply pipe to each of the plurality of second spray pipes; and

 an emergency backflow prevention valve configured to prevent backflow from the cleaning liquid supply pipe to the cleaning liquid supply pump when the cleaning liquid supply pump is stopped, the emergency backflow prevention valve being disposed between the
20 cleaning liquid supply pump and a connection portion where the cleaning liquid supply pipe is connected to the first branch pipe.

[Claim 2] The marine desulfurization device according to claim 1, further comprising a flow regulating valve disposed in the first branch pipe and configured to open at a predetermined
25 opening degree when the cleaning liquid supply pump is operating.

[Claim 3] The marine desulfurization device according to claim 2,

 wherein the flow regulating valve is configured to open at a larger opening degree when

the cleaning liquid supply pump is stopped than when the cleaning liquid supply pump is operating.

[Claim 4] The marine desulfurization device according to claim 2, further comprising:

5 a second branch pipe connecting the cleaning liquid supply pipe to each of the plurality of second spray pipes; and

an emergency on-off valve disposed in the second branch pipe and configured to close when the cleaning liquid supply pump is operating and to open when the cleaning liquid supply pump is stopped.

10

[Claim 5] The marine desulfurization device according to any one of claims 1 to 4,

wherein the spraying device further includes a plurality of first spray nozzles disposed in each of the plurality of first spray pipes and configured to inject the cleaning liquid upward.

15 [Claim 6] The marine desulfurization device according to any one of claims 1 to 4,

wherein the absorption tower includes:

an absorber body part having a first interior space through which the exhaust gas flows upward from below, the first interior space being part of the interior space; and

20 an exhaust gas introduction part having a second interior space through which the exhaust gas flows downward from above for introducing the exhaust gas from the exhaust gas inlet to the first interior space, the second interior space being part of the interior space, and

wherein the plurality of first spray pipes is arranged in the first interior space, and the plurality of second spray pipes is arranged in the second interior space.

25 [Claim 7] The marine desulfurization device according to claim 6,

wherein the spraying device further includes a plurality of second spray nozzles disposed in each of the plurality of second spray pipes, and

wherein the plurality of second spray nozzles includes a plurality of second upward spray

nozzles configured to inject the cleaning liquid upward.

[Claim 8] The marine desulfurization device according to any one of claims 1 to 4,

5 wherein the absorption tower includes an absorber body part having a first interior space through which the exhaust gas flows upward from below, the first interior space being part of the interior space, and

wherein the plurality of first spray pipes and the plurality of second spray pipes are arranged in the first interior space.

10 [Claim 9] The marine desulfurization device according to claim 8,

wherein the absorber body part includes a packing layer disposed below the first spray pipes and above the second spray pipes in the first interior space,

wherein the spraying device further includes a plurality of second spray nozzles disposed in each of the plurality of second spray pipes, and

15 wherein the plurality of second spray nozzles includes:

a plurality of second upward spray nozzles configured to inject the cleaning liquid upward; and

a plurality of second downward spray nozzles disposed in proximity to the exhaust gas inlet and configured to inject the cleaning liquid downward.

20