

Description

Title of Invention: SYSTEM USING AMMONIA

Technical Field

5 [0001] The present disclosure relates to a system using ammonia. The present application claims the benefit of priority based on Japanese Patent Application No. 2022-49707 filed on March 25, 2022, the contents of which are incorporated herein by reference.

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Background Art

[0002] Ammonia is used in a variety of systems. For example, Patent Literature 1 discloses a power generation facility that includes a boiler using ammonia as fuel. In
15 this power generation facility, liquid ammonia contained in a tank is pressurized by a pump. The pressurized liquid ammonia is heated and vaporized in a vaporizer. The gaseous ammonia is supplied to the boiler and burned.

20 Citation List

Patent Literature

[0003] Patent Literature 1: JP 2019-203637 A

Summary

25 Technical Problem

[0004] For example, when shutting down the system as described above, pressurized or heated ammonia remaining in

piping may be purged from the piping to prevent leakage.

However, in such a system, returning pressurized or heated ammonia directly to the tank will lead to an increase in pressure and temperature in the tank. Accordingly, when
5 purging ammonia, the ammonia must be depressurized.

Furthermore, since ammonia is toxic, it cannot be released directly into the atmosphere. Accordingly, for example, purged ammonia may be disposed of by dissolving in water or burning in a flare stack. Disposal of ammonia, however,

10 results in economic losses.

[0005] The purpose of the present disclosure is to provide a system using ammonia that can reduce the amount of ammonia disposed of.

15 Solution to Problem

[0006] A system according to one aspect of the present disclosure includes: a tank that stores liquid ammonia; a pressurizer that fluidly communicates with the tank and pressurizes liquid ammonia or gaseous ammonia; a pressure-
20 reducing valve that depressurizes ammonia pressurized by the pressurizer; a gas-liquid separation tank that separates gaseous ammonia from liquid ammonia that are generated by the depressurization; an ammonia disposal device that disposes of gaseous ammonia from the gas-liquid separation tank; and a
25 return line that returns liquid ammonia from the gas-liquid separation tank to the tank.

[0007] The system may include a pump that is provided on

the return line, the pump sucking liquid ammonia from the gas-liquid separation tank and sending the liquid ammonia to the tank.

[0008] The system may include a heat exchanger that is provided between the pressurizer and the pressure-reducing valve and cools ammonia pressurized by the pressurizer with gaseous ammonia from the gas-liquid separation tank.

[0009] Ammonia sent from the pressurizer to the pressure-reducing valve may be liquid ammonia.

10 [0010] Ammonia sent from the pressurizer to the pressure-reducing valve may be gaseous ammonia.

[0011] The ammonia disposal device may include at least one of an abatement tank or a flare stack.

15 Advantageous Effects of Invention

[0012] According to the present disclosure, the amount of ammonia disposed of can be reduced.

Brief Description of Drawings

20 [0013] Fig. 1 is a schematic diagram of a system according to a first embodiment.

Fig. 2 is a schematic diagram of a system according to a second embodiment.

25 Description of Embodiments

[0014] Embodiments of the present disclosure will be described in detail below with reference to the accompanying

drawings. Specific dimensions, materials, and numerical values described in the embodiments are merely examples for a better understanding, and do not limit the present disclosure unless otherwise specified. In this specification and the drawings, duplicate explanations are omitted for elements having substantially the same functions and configurations by assigning the same sign. Furthermore, elements not directly related to the present disclosure are omitted from the figures.

10 [0015] Fig. 1 is a schematic diagram of a system 100 according to a first embodiment. For example, the system 100 comprises a tank 1, a pressurizer 2, a gas turbine 3, a gas-liquid separation tank 4, an abatement tank 5, a flare stack 6, a pump 7, and a controller 90. The system 100 may further
15 comprise other components. Furthermore, the system 100 may not comprise one or more of the above components.

[0016] The system 100 may use ammonia stored in the tank 1 for various purposes. In the present embodiment, the system 100 uses ammonia as fuel which a combustor 31 of the
20 gas turbine 3 burns. In another embodiment, the system 100 may comprise a boiler that burns ammonia and a steam turbine that is operated by steam generated by the boiler. In still another embodiment, the system 100 may be a plant that uses ammonia as a feedstock to produce a product. The system 100
25 is not limited thereto, and may include various facilities that use ammonia.

[0017] The tank 1 stores ammonia. Specifically, the

tank 1 stores liquid ammonia. The tank 1 is connected to the pressurizer 2 by piping P1. The liquid ammonia stored in the tank 1 is supplied to the pressurizer 2 via the piping P1.

[0018] The pressurizer 2 pressurizes ammonia from the

5 tank 1. The pressurizer 2 supplies the pressurized ammonia to the gas turbine 3. In the present embodiment, ammonia is supplied to the gas turbine 3 in a liquid state. In this case, for example, the pressurizer 2 may be a pump. In another embodiment, the system 100 may comprise a vaporizer
10 on the piping P1, and ammonia may be supplied in a gaseous state to the gas turbine 3. For example, in the case where the pressurizer 2 pressurizes gaseous ammonia, the pressurizer 2 may be a compressor.

[0019] Piping P2 branches off from the piping P1. The

15 piping P2 is connected to the tank 1. The piping P2 can return ammonia that has passed through the pressurizer 2 to the tank 1.

[0020] The piping P2 is provided with a valve V1. The valve V1 may be communicatively connected to the controller

20 90 by wire or wirelessly, and may be controlled by the controller 90. The controller 90 adjusts pressure in the piping P1 on a side positioned downstream of the pressurizer 2 and in the piping P2, by controlling an opening degree of the valve V1.

25 [0021] For example, the piping P1 branches into, at a side downstream of a branching point of the piping P2, piping P3 that is connected to the gas turbine 3, and piping P4 that

is connected to the gas-liquid separation tank 4. In another embodiment, for example, the piping P1 may branch into the piping P3 and the piping P4 at a side upstream of the branching point of the piping P2, and the piping P2 may
5 branch off from the piping P3 or the piping P4.

[0022] The piping P3 is provided with a valve V2. The valve V2 may be communicatively connected to the controller 90 by wire or wirelessly, and may be controlled by the controller 90. The controller 90 adjusts the amount of
10 ammonia supplied to the gas turbine 3 by controlling an opening degree of the valve V2.

[0023] The gas turbine 3 includes the combustor 31 and a turbine 32. The combustor 31 burns ammonia supplied from the tank 1. Exhaust gas generated in the combustor 31 is
15 supplied to the turbine 32 and used for operation such as power generation.

[0024] The piping P4 is provided with a pressure-reducing valve Vd. The pressure-reducing valve Vd may be communicatively connected to the controller 90 by wire or
20 wirelessly, and may be controlled by the controller 90. For example, the controller 90 may close the pressure-reducing valve Vd when there is no need to dispose of ammonia, and may open the pressure-reducing valve Vd when there is a need to dispose of ammonia, e.g., to shut down the system 100 and
25 purge ammonia from the piping P1. A primary side (high pressure side) of the pressure-reducing valve Vd is in fluid communication with the pressurizer 2, and a secondary side

(low pressure side) is in fluid communication with the gas-liquid separation tank 4. Accordingly, when the pressure-reducing valve Vd is opened, ammonia that is pressurized by the pressurizer 2 is depressurized when passing through the pressure-reducing valve Vd.

[0025] When liquid ammonia passes through the pressure-reducing valve Vd, a part of the liquid ammonia is vaporized by flash evaporation due to the depressurization.

Accordingly, liquid ammonia and gaseous ammonia are sent from the pressure-reducing valve Vd to the gas-liquid separation tank 4. The ammonia sent to the gas-liquid separation tank 4 is separated into liquid ammonia and gaseous ammonia. The liquid ammonia is accumulated in a lower part of the gas-liquid separation tank 4, and the gaseous ammonia is accumulated in an upper part of the gas-liquid separation tank 4.

[0026] When gaseous ammonia passes through the pressure-reducing valve Vd, a part of the gaseous ammonia is cooled by adiabatic expansion due to the depressurization, and is

condensed into liquid ammonia. Accordingly, also in this case, liquid ammonia and gaseous ammonia are sent from the pressure-reducing valve Vd to the gas-liquid separation tank 4. The ammonia sent to the gas-liquid separation tank 4 is separated into liquid ammonia and gaseous ammonia. The liquid ammonia is accumulated in the lower part of the gas-liquid separation tank 4, and the gaseous ammonia is accumulated in the upper part of the gas-liquid separation

tank 4.

[0027] The gas-liquid separation tank 4 is connected to the tank 1 by piping (return line) P5. The piping P5 is provided with the pump 7. The Pump 7 sucks the liquid ammonia accumulated in the gas-liquid separation tank 4, and returns the liquid ammonia to the tank 1. Furthermore, the gas-liquid separation tank 4 is depressurized due to the suction by the pump 7. In addition, the gas-liquid separation tank 4 may be depressurized even without the suction by the pump 7, since the abatement tank 5 and the flare stack 6 with an opened valve V3 (described below) have atmospheric pressure. Accordingly, a part of the gaseous ammonia accumulated in the gas-liquid separation tank 4 may be condensed into liquid ammonia. As such, the amount of liquid ammonia accumulated in the gas-liquid separation tank 4, i.e., the amount of liquid ammonia returned to the tank 1, can be increased.

[0028] The gas-liquid separation tank 4 is connected to the abatement tank 5 by piping P6. The gaseous ammonia in the gas-liquid separation tank 4 is sent to the abatement tank 5 by the piping P6. The piping P6 is provided with a check valve Vc. The check valve Vc prevents fluid in the abatement tank 5 from flowing back into the gas-liquid separation tank 4.

[0029] In the abatement tank 5, the gaseous ammonia is dissolved in water. For example, the water that has absorbed ammonia may be disposed of.

[0030] The gas-liquid separation tank 4 is connected to the flare stack 6 by piping P7. The gaseous ammonia in the gas-liquid separation tank 4 is sent to the flare stack 6 by the piping P7. The piping P7 is provided with a valve V3.

5 The valve V3 may be communicatively connected to controller 90 by wire or wirelessly, and may be controlled by the controller 90. The controller 90 adjusts the amount of ammonia supplied to the flare stack 6 by controlling an opening degree of the valve V3.

10 [0031] Gaseous ammonia is burned in the flare stack 6. Since ammonia has poor combustibility, the flare stack 6 may further use another fuel having good combustibility for a pilot light. For example, the controller 90 may close the valve V3 when the gaseous ammonia in the gas-liquid
15 separation tank 4 can be disposed of by the abatement tank 5, and may open the valve V4 to send the gaseous ammonia in the gas-liquid separation tank 4 to the flare stack 6 when the gaseous ammonia in the gas-liquid separation tank 4 cannot be disposed of by the abatement tank 5, e.g., when the abatement
20 tank 5 is full with water that has absorbed ammonia.

[0032] As described above, the system 100 comprises the abatement tank 5 and the flare stack 6 as an ammonia disposal device to dispose of the gaseous ammonia from the gas-liquid separation tank.

25 [0033] The controller 90 controls the system 100 in whole or in part. The controller 90 includes, for example, a processor 90a, a memory 90b, and a connector 90c, and these

components are connected to each other via buses. For example, the processor 90a includes a CPU (Central Processing Unit) or the like. For example, the memory 90b includes a hard disk, a ROM in which programs and the like are stored, and a RAM as a work area. The controller 90 is communicatively connected to each component of the system 100 by wire or wirelessly via the connector 90c. For example, the controller 90 may further include other components such as a display such as an LCD or a touch panel, and an input device such as a keyboard, buttons or a touch panel. For example, the operations of the controller 90 described above may be realized by executing programs stored in the memory 90b on the processor 90a.

[0034] The system 100 as described above comprises the tank 1 that stores liquid ammonia, the pressurizer 2 that fluidly communicates with the tank 1 and pressurizes liquid ammonia or gaseous ammonia, the pressure-reducing valve Vd that depressurizes ammonia pressurized by the pressurizer 2, the gas-liquid separation tank 4 that separates gaseous ammonia from liquid ammonia that are generated by the depressurization, the abatement tank 5 and the flare stack 6 that dispose of gaseous ammonia from the gas-liquid separation tank 4, and the return line P5 that returns liquid ammonia from the gas-liquid separation tank 4 to the tank 1. According to such a configuration, when liquid ammonia pressurized by the pressurizer 2 passes through the pressure-reducing valve Vd, a part of the liquid ammonia is vaporized

by flash evaporation due to the depressurization. The liquid ammonia and the gaseous ammonia are subsequently separated from each other in the gas-liquid separation tank 4.

Accordingly, a part of the liquid ammonia pressurized by the
5 pressurizer 2 can be returned to the tank 1 under reduced pressure. Furthermore, when gaseous ammonia pressurized by the pressurizer 2 passes through the pressure-reducing valve Vd, a part of the gaseous ammonia is cooled by adiabatic expansion due to the depressurization, and is condensed into
10 liquid ammonia. The liquid ammonia and the gaseous ammonia are subsequently separated from each other in the gas-liquid separation tank 4. Accordingly, also in this case, a part of the gaseous ammonia pressurized by the pressurizer 2 can be returned to the tank 1 in a depressurized liquid state. As
15 such, according to the above configuration, the amount of ammonia disposed of can be reduced.

[0035] Furthermore, the system 100 comprises the pump 7 provided on the return line P5, the pump 7 sucking liquid ammonia from the gas-liquid separation tank 4 and sending the
20 liquid ammonia to the tank 1. According to such a configuration, the gas-liquid separation tank 4 is depressurized due to the suction by the pump 7. Accordingly, it is possible to enhance the condensation of a part of the gaseous ammonia accumulated in the gas-liquid separation tank
25 4 into liquid ammonia. As such, the amount of liquid ammonia returned to the tank 1 can be increased.

[0036] Furthermore, in the system 100, the ammonia sent

from the pressurizer 2 to the pressure-reducing valve Vd may be liquid ammonia or gaseous ammonia. In either case, a part of the ammonia pressurized by the pressurizer 2 can be returned to the tank 1 in a depressurized state, reducing the amount of ammonia that is disposed of.

[0037] Furthermore, in the system 100, the ammonia disposal device includes the abatement tank 5 or the flare stack 6. For example, in another embodiment, the ammonia disposal device may include at least one of the abatement tank 5 or the flare stack 6. The ammonia disposal device is not limited thereto, and may be any other device capable of disposing of gaseous ammonia.

[0038] Next, a system according to another embodiment will be described.

15 [0039] Fig. 2 is a schematic diagram of a system 100A according to a second embodiment. The system 100A is different from the system 100 according to the first embodiment described above in that the system 100A comprises a heat exchanger 8. The system 100A may be the same as the system 100 according to the first embodiment in other respects.

[0040] The heat exchanger 8 is arranged between the gas-liquid separation tank 4 and the abatement tank 5 on the piping P6. In another embodiment, the heat exchanger 8 may be arranged between the gas-liquid separation tank 4 and the flare stack 6 on the piping P7, instead of the piping P6. Furthermore, the heat exchanger 8 is arranged between the

pressurizer 2 and the pressure-reducing valve Vd on the piping P1. In another embodiment, the heat exchanger 8 may be arranged between the pressurizer 2 and the pressure-reducing valve Vd on the piping P4, instead of the piping P1.

5 In the heat exchanger 8, the ammonia pressurized by the pressurizer 2 is cooled by the gaseous ammonia from the gas-liquid separation tank 4. According to such a configuration, more liquid ammonia is obtained by the depressurization at the pressure-reducing valve Vd.

10 [0041] The system 100A as described above has the similar effects to those of the system 100 according to the first embodiment. In particular, the system 100A comprises the heat exchanger 8 that is provided between the pressurizer 2 and the pressure-reducing valve Vd, and cools the ammonia
15 pressurized by the pressurizer 2 with the gaseous ammonia from the gas-liquid separation tank 4. According to such a configuration, more liquid ammonia is obtained by the depressurization at the pressure-reducing valve Vd. As such, the amount of liquid ammonia returned to the tank 1 can be
20 increased.

[0042] Although the embodiments of the present disclosure have been described above with reference to the accompanying drawings, the present disclosure is not limited thereto. It is obvious that a person skilled in the art can
25 conceive of various examples of variations or modifications within the scope of the claims, which are also understood to belong to the technical scope of the present disclosure.

[0043] For example, in the above embodiments, the systems 100 and 100A comprise the pump 7. In another embodiment, the system may not comprise the pump 7. In this case, for example, the pressure-reducing valve Vd may be controlled so that an internal pressure of the gas-liquid separation tank 4 is higher than an internal pressure of the tank 1. The differential pressure between the gas-liquid separation tank 4 and the tank 1 allows liquid ammonia to flow from the gas-liquid separation tank 4 to the tank 1. In this case, since a part of the liquid ammonia from the gas-liquid separation tank 4 may vaporize in the tank 1, the system may further comprise a Boil Off Gas (BOG) compressor that is connected to the tank 1. The BOG compressor allows the vaporized ammonia to return to liquid ammonia. The BOG compressor can be used to return vaporized ammonia to liquid ammonia. Furthermore, for example, the gas-liquid separation tank 4 may be placed at a higher position so that the internal pressure of the gas-liquid separation tank 4 is higher than the internal pressure of the tank 1.

[0044] The present disclosure can promote the use of ammonia to reduce CO₂ emissions, thus contributing to Sustainable Development Goals (SDGs), Goal 7 "Ensure access to affordable, reliable, sustainable and modern energy," for example.

Reference Signs List

[0045] 1: tank

2: pressurizer
4: gas-liquid separation tank
4A: gas-liquid separation tank
5: abatement tank (ammonia disposal device)
5 6: flare stack (ammonia disposal device)
7: pump
8: heat exchanger
41: first chamber
42: second chamber
10 100: system
100A: system
P5: piping (return line)
Vd: pressure-reducing valve

Claims

[Claim 1] A system using ammonia, comprising:

- a tank that stores liquid ammonia;
- a pressurizer that fluidly communicates with the tank and pressurizes liquid ammonia or gaseous ammonia;
- a pressure-reducing valve that depressurizes ammonia pressurized by the pressurizer;
- a gas-liquid separation tank that separates gaseous ammonia from liquid ammonia that are generated by the depressurization;
- an ammonia disposal device that disposes of gaseous ammonia from the gas-liquid separation tank;
- a return line that returns liquid ammonia from the gas-liquid separation tank to the tank; and
- a heat exchanger that is provided between the pressurizer and the pressure-reducing valve and cools ammonia pressurized by the pressurizer with gaseous ammonia from the gas-liquid separation tank.

[Claim 2] The system according to claim 1, comprising:

- a pump that is provided on the return line, the pump sucking liquid ammonia from the gas-liquid separation tank and sending the liquid ammonia to the tank.

[Claim 3] The system according to claim 1 or 2, wherein ammonia sent from the pressurizer to the pressure-reducing valve is liquid ammonia.

[Claim 4] The system according to claim 1 or 2, wherein ammonia sent from the pressurizer to the pressure-reducing valve is gaseous ammonia.

[Claim 5] The system according to claim 1 or 2, wherein the ammonia disposal device includes at least one of an abatement tank or a flare stack.

[Claim 6] The system according to claim 3, wherein the ammonia disposal device includes at least one of an abatement tank or a flare stack.

[Claim 7] The system according to claim 4, wherein the ammonia disposal device includes at least one of an abatement tank or a flare stack.