

DESCRIPTION**TITLE OF THE INVENTION: Gas treatment system comprising a monitoring unit**

5 [0001] The present invention relates to the field of liquefied gas transport vessels, in particular LNG carriers, and to the field of cooling equipment. More specifically, the invention relates to a system for treating a gas configured to supply the engines of such vessels and whose cooling at the inlet of a compression device is optimized.

[0002] Such vessels comprise a hold fitted out to contain one or more tanks for transporting
10 gas in the liquid state, these tanks having a capacity of several thousand or even several tens of thousands of cubic meters. When natural gas is used, it is kept in the tanks at around -163°C (degrees Celsius), at atmospheric pressure. The tanks are therefore watertight and thermally insulated with a double layer of insulation. However, since the liquefied natural gas (LNG) tends to evaporate, for example as a result of a reduction in the pressure of the
15 gas in the tanks or a flow of heat flowing through the tank walls despite the double insulation, the upper portion of each tank, referred to as the tank gaseous headspace, is filled with gas in the vapor state.

[0003] LNG that evaporates naturally and accumulates in the gaseous headspace is also called NBOG (Natural Boil-Off Gas). This NBOG is generally used as fuel for one or more
20 of the engines of the vessel. The engines on these vessels must be supplied with NBOG at pressures higher than the pressure of the NBOG in the tank gaseous headspace and at a given temperature. To this end, these vessels are equipped with one or more compression devices configured to supply the engines of the vessel with NBOG at a pressure suitable for these engines. However, when these compression devices are operating, they help to
25 heat the NBOG to temperatures above the engine intake temperature. Among these compression devices, two-stage compression devices are implemented and it is known to cool the NBOG at the inlet to such compression devices so that the NBOG at the inlet to the engines is at an acceptable temperature for the latter.

[0004] The cooling of the NBOG at the inlet to the compression device is conventionally
30 obtained by spraying natural gas in the liquid state from a tank and circulating in a specific line, by means of a pumping member immersed in the tank. In the prior art system, the pumping member operates continuously to cool the NBOG. The operation of the pumping member generates heat within the tank, which increases the amount of NBOG generated in the tank. Such uninterrupted operation of the pumping member helps to reduce the

energy balance of operational losses of evaporated gas during a voyage of the vessel, also known as the operational Boil-Off Rate (BOR) of a vessel.

[0005] The present invention is part of this context and is configured to overcome at least some of the disadvantages of the prior art. In particular, the present invention provides a gas treatment system wherein the generation of NBOG in the tank as a result of the calories generated by the pumping member is limited by a monitored operation of said pumping member.

[0006] Thus, the present invention relates to a gas treatment system comprising at least a first line configured to ensure the circulation of a gas in a vapor state contained in a storage tank and a second line configured to ensure the circulation of at least part of said gas contained in a liquid state in the storage tank, the first line being configured to connect at least one gaseous headspace of said storage tank to a gas-consuming apparatus and comprising at least one compression device configured to supply the gas-consuming apparatus with gas and a phase separator arranged between the gaseous headspace and the compression device, the second line comprising at least one pumping member configured to supply the second line with gas in the liquid state coming from the storage tank, said second line extending at least between said pumping member and the first line, the second line being fluidly connected to the first line between the gaseous headspace and the phase separator, the second line being configured to deliver gas in the liquid state into the first line so as to lower the temperature of the gas in the vapor state circulating in the first line, characterized in that the gas treatment system comprises a monitoring unit which gives an operating indication and/or controls the operation of the pumping member according to at least one temperature of the gas in the vapor state that is determined at the inlet of the compression device.

[0007] The gas treatment system allows to modulate the activity of the pumping member according to the cooling requirement of the gas in the vapor state circulating in the first line. This gas in vapor state is produced by the natural evaporation of the gas contained in liquid state in the storage tank.

[0008] The temperature of the gas in the vapor state at the inlet of the compression device determines the temperature of said gas at the outlet of the compression device when the gas in the vapor state is compressed to be sent to the gas-consuming apparatus. In particular, when the gas entering the compression device is too hot, the monitoring unit is able to activate the pumping member to cool the gas in the vapor state by spraying gas in the liquid state. It should be noted that the monitoring unit may give an indication to activate the pumping member. This indication may, for example, be a signal to an operator to

manually control the activation of the pumping member. This spraying is carried out before said cooled gas reaches the phase separator. Thus, although the gas in vapor state has been cooled by the projection of gas in liquid state, it is ensured that only the gaseous phase of the gas circulating in the first line reaches the compression device.

5 [0009] The temperature of the gas at the inlet of the compression device may be determined as a function of a plurality of parameters which may be taken alone or in combination with one another. The temperature of the gas at the inlet of the compression device may in particular be defined as a function of the flow rate of the gas circulating in the first, the movements of the gas in the liquid state contained in the storage tank, the temperature of
10 the gas contained in the vapor state in the gaseous headspace of the storage tank or even directly by measuring the temperature of the gas at the inlet of the compression device.

[0010] The meeting of the gas in the liquid state circulating in the second line with the gas in the vapor state circulating in the first line may generate an expansion of the gas in the liquid state which vaporizes on contact with the gas in the vapor state circulating in the first
15 line, while lowering the temperature of the latter.

[0011] The gas treatment system thus allows not to leave the pumping member operating continuously but to control its operation according to the cooling requirement of the gas in the vapor state circulating in the first line.

[0012] According to a characteristic of the invention, the compression device is a
20 compression device comprising at most two compression stages. In two-stage compression devices, the cooling of the gas compressed by the compression device between two compression stages is complex. The gas must therefore be cooled before entering the compression device.

[0013] According to a characteristic of the invention, the pumping member is configured to
25 assume at least a first operating state wherein the pumping member generates the circulation of the gas in the liquid state in the second line and to assume a second operating state wherein the pumping member does not generate circulation of the gas in the liquid state in the second line, the monitoring unit being able to switch the pumping member from one of said operating states to the other. By controlling the pumping member, it is possible
30 to generate a circulation of gas in the liquid state in the second line, or to generate no circulation at all. By switching the pumping member from one operating state to the other, the monitoring unit is able to control, by means of the pumping member, the cooling of the gas in the vapor state circulating in the first line.

[0014] According to a characteristic of the invention, the monitoring unit is able to define a
35 threshold temperature value, the pumping member being in its first operating state when

the temperature of the gas determined at the inlet of the compression device is greater than the threshold temperature value, the pumping member being in its second operating state when the temperature of the gas determined at the inlet of the compression device is less than the threshold temperature value. The threshold temperature value is a value
5 determined by the monitoring unit and compared with the temperature of the gas in the vapor state at the inlet of the compression device in order to choose when to activate the pumping member and when to deactivate the pumping member.

[0015] According to a characteristic of the invention, the threshold temperature value is variable. The threshold temperature value is an evolving parameter that depends on the
10 conditions wherein the gas treatment system operates. It is understood that the threshold temperature value is not a predetermined fixed value but a value that fluctuates over time.

[0016] According to a characteristic of the invention, the threshold temperature value is a function of at least the temperature of the gas present in the gaseous headspace of the storage tank. The gas in the vapor state circulating in the first line comes from the gaseous
15 headspace in the storage tank, so the temperature value adapts to the temperature of the gas in the gaseous headspace.

[0017] According to an alternative or complementary characteristic of the invention, the threshold temperature value is a function of at least the flow rate of gas circulating in the first line between the phase separator and the compression device. The greater the gas
20 circulate in the first line, the lower the temperature of said gas will tend to be, which limits the use of the pumping member.

[0018] According to an alternative or complementary characteristic of the invention, the threshold temperature value is a function at least of the movement of the gas in the liquid state contained in the storage tank. The greater the movement of the gas contained in the
25 liquid state in the tank, the more gas will be generated in the vapor state. The greater the volume of gas in the vapor state in the gaseous headspace in the storage tank, the greater the volume of gas in the vapor state circulating towards the compression device. Furthermore, the greater the volume of gas in the vapor state, the lower the temperature of the latter. In this way, the control of the pumping member and/or the operating indication of
30 the pumping member are adapted to the volume of gas in the vapor state generated in the gaseous headspace in the storage tank.

[0019] According to an alternative or complementary characteristic of the invention, the threshold temperature value is a function of at least one temperature of at least one duct forming the first line. The higher the temperature of the duct forming the first line, the higher
35 the temperature of the gas circulating through this duct. Thus, by taking into account the

temperature of the duct, the monitoring unit may determine the impact of this parameter on the rise in temperature of the gas contained in said duct, and thus decide whether or not to operate the pumping member.

5 [0020] The present invention also relates to a gas treatment assembly comprising a storage tank and a gas treatment system, the pumping member being immersed in the gas contained in the liquid state in the storage tank.

[0021] The present invention also relates to a floating structure comprising a gas treatment system or a gas treatment assembly, as described in this document.

10 [0022] The present invention also relates to a method for treating a gas by a gas treatment system implementing at least:

- a first step during which the monitoring unit collects at least one data relating to the temperature of the gas in the vapor state determined at the inlet of the compression device and gives an operating indication and/or controls the pumping member as a function of said data relating to the temperature of the gas in the vapor state determined
- 15 at the inlet of the compression device.

[0023] According to a characteristic of the invention, the treatment method implements at least:

- a second step wherein the monitoring unit determines a threshold temperature value,
 - a third step during which the monitoring unit compares the data with the threshold
- 20 temperature value and gives an operating indication and/or controls the pumping member as a function of said comparison.

[0024] According to a characteristic of the invention, during the third step, if the data relating to the temperature of the gas in the vapor state determined at the inlet of the compression device is greater than the threshold temperature value, then the monitoring unit gives an

25 operating indication and/or controls the pumping member so that the pumping member is in its first operating state, and if the data relating to the temperature of the gas in the vapor state determined at the inlet of the compression device is less than the threshold temperature value, then the monitoring unit gives an operating indication and/or controls the pumping member so that the pumping member is in its second operating state.

30 [0025] According to a characteristic of the invention, the treatment method implements at least one additional step during which the monitoring unit collects at least one data relating to the temperature of the gas in the vapor state present in the gaseous headspace of the storage tank in order to determine the threshold temperature value.

35 [0026] According to a characteristic of the invention, the treatment method implements at least one additional step during which the monitoring unit collects at least one data relating

to the flow rate of gas in the vapor state circulating in the first line between the phase separator and the compression device in order to determine the threshold temperature value.

5 [0027] According to a characteristic of the invention, the treatment method implements at least one additional step during which the monitoring unit collects at least one data relating to the temperature of at least one duct forming the first line in order to determine the threshold temperature value.

[0028] It should be noted that these additional steps may be carried out prior to or simultaneously with the second step.

10 [0029] Other characteristics and advantages of the invention will become apparent from the following description, on the one hand, and from a number of embodiments given by way of indication and without limitation with reference to the appended schematic drawings, on the other hand, wherein:

15 [0030] [Fig.1] schematically represents a general view of a gas treatment system allowing a gas in vapor state to be cooled by a gas in liquid state by means of a pumping member controlled by a monitoring unit;

[0031] [Fig.2] is a schematic representation of the gas treatment system shown in Figure 1 when the pumping member is in its second operating state and is not generating a circulation of a gas;

20 [0032] [Fig.3] is a schematic representation of the gas treatment system shown in Figure 1 when the pumping member is in its first operating state and generates a circulation of a gas;

[0033] [Fig.4] shows a floating structure comprising a gas treatment system;

25 [0034] The characteristics, variants and the different embodiments of the invention may be associated with one another in various combinations, insofar as they are not incompatible or mutually exclusive. In particular, it will be possible to imagine variants of the invention comprising only a selection of characteristics described hereinafter in isolation from the other characteristics described, if this selection of characteristics is sufficient to confer a technical advantage and/or to differentiate the invention from the prior art.

[0035] In the figures, the elements common to several figures retain the same reference.

30 [0036] It should be noted that in the attached Figures 1 to 3, the lines representing ducts through which a gas circulates are shown with a greater thickness when a gas circulates through said ducts and with a lesser thickness when no gas circulates through said ducts. In addition, the dotted lines represent an exchange of information between the monitoring unit and an associated element of the system according to the invention.

[0037] Figure 1 schematically illustrates a gas treatment system 2 according to one embodiment of the invention. As shown in Figure 1, the gas treatment system 2 is integrated within a floating structure 4, such a floating structure 4 being shown in Figure 4. This floating structure 4 is configured to ensure the temporary storage and/or the transport of liquefied gas. In what follows, the invention is described in a non-limitative manner in the context of the storage and/or transport of liquefied natural gas, which will be referred to in the following description by the acronym "LNG". To this end, the floating structure 4 comprises at least one LNG storage tank 6, in this case three storage tanks 6. It should be noted that the description in relation to a storage tank 6 that will be made applies *mutatis mutandis* to other storage tanks 6.

[0038] The LNG is stored in a storage tank 6 at a temperature of approximately -163°C (degrees Celsius) allowing it to be maintained in a liquid state at atmospheric pressure. The storage tank 6 comprises a gaseous headspace 8 within which the gas resulting from the natural evaporation of the gas contained in the liquid state in the storage tank 6, which will be referred to in the following description by the acronym NBOG for "Natural Boil-Off Gas", accumulates in the gaseous headspace 8. When the storage tank 6 is full, this gaseous headspace 8 represents approximately 15% of the volume of the storage tank 6 and allows changes in pressure within the storage tank 6 resulting from the formation of the NBOG to be contained at a safe pressure.

[0039] This gaseous headspace 8 is fluidly connected to a first line 10 in which the gas in the vapor state circulates as a result of the natural evaporation of the gas contained in the liquid state in the storage tank 6. Figure 1 shows that the first line 10 is connected to the gaseous headspace 8 of each of the storage tanks 6. In this way, all the NBOG generated in the storage tanks 6 may circulate through the first line 10.

[0040] The first line 10 connects the gaseous headspace 8 to at least one gas-consuming apparatus 12. The gas-consuming apparatus 12 may be a propulsion engine 14 used to set the floating structure 4 in motion, a generator 16 configured to generate an electric current, or a gas combustion unit 18, commonly referred to as a "burner".

[0041] In the embodiment shown, the first line 10 is connected to the propulsion engine 14, the generator 16 and the combustion unit 18. To this end, a supply valve 19 is associated with each of said gas-consuming apparatus 12 to independently monitor the gas supply to each of these gas-consuming apparatus 12.

[0042] The first line 10 comprises, between the gaseous headspace 8 and the gas-consuming apparatus 12, a compression device 20 configured to compress the gas circulating in the first line 10 before it reaches the gas-consuming apparatus 12 to a given

pressure. In the embodiment shown, the compression device 20 is formed by a main line 22 comprising a first compressor 24 and an auxiliary line 26, arranged in parallel with the main line 28, comprising a second compressor 30. The main line 22 and the auxiliary line 26 meet at the outlet of the first compressor 24 and of the second compressor 30 before
 5 joining the gas-consuming apparatus 12. The first compressor 24 and the second compressor 30 operate in redundancy, with the second compressor 30 taking over if the first compressor 24 malfunctions.

[0043] The compression device 20, in this case the first compressor 24 or the second compressor 30, comprises a maximum of two compression stages. In the embodiment
 10 shown, the first compressor 24 and the second compressor 30 each comprise two compression stages. In such a configuration of the compression device, the cooling of the compressed gas between two compression stages is complex to implement.

[0044] The main line 22 comprises a first valve 32 and the auxiliary line 26 comprises a second valve 34. The first valve 32 and the second valve 34 independently monitor the gas
 15 flow from the first line 10 to the inlet of the first compressor 24 or of the second compressor 30.

[0045] Between the gaseous headspace 8 of the storage tank 6 and the compression device 20, the first line 10 comprises a phase separator 36 configured to separate the liquid phase from the gaseous phase of the gas circulating in the first line 10. This phase separator 36
 20 ensures that only the gaseous phase of said gas is sent towards the compression device 20 while the liquid phase returns to the storage tank 6 by means of a return line 38.

[0046] The gas treatment system 2 also comprises a second line 40 extending between a pumping member 42 and the first line 10. The second line 40 is used to circulate gas in the liquid state contained in the storage tank 6 to the first line 10.

25 [0047] This second line 40 is used to cool the NBOG, i.e., the gas resulting from the natural evaporation of the gas contained in the liquid state in the storage tank 6, circulating in the first line 10.

[0048] In fact, at least some of the NBOG compressed by the compression device is configured to supply the propulsion engine 14 so as, for example, to set the floating structure
 30 4 in motion. The propulsion engine 14 requires the gas compressed by the compression device 20 and entering the propulsion engine 14 to be sufficiently cold. During operation of the compression device 20, the compressed gas heats up under the effect of the compression produced by the compression device 20.

[0049] In addition, the gas resulting from the natural evaporation of the gas contained in the
 35 liquid state in the storage tank 6 and accumulating in the gaseous headspace 8 is at a

temperature of about -120°C . However, as the NBOG circulates from the gaseous headspace 8 to the inlet of the compression device 20, the temperature of the NBOG rises to around -110°C . At this temperature of the NBOG at the inlet of the compression device 20, the compressed gas may not be admitted to the propulsion engine. The NBOG then
 5 needs to be cooled to a temperature of no more than -120°C .

[0050] To this end, the second line 40 allows the NBOG circulating in the first line 10 to be cooled so that the temperature of the gas at the inlet to the compression device 20 is sufficiently cold, i.e., at most -120°C , for the gas compressed by the compression device 20 to be at a temperature acceptable to the propulsion engine 14.

10 [0051] The gas in the liquid state contained in the second line 40 is at a temperature of approximately -160°C . It should be noted that this gas may, depending on the application, heat up as it circulates through the second line 40. However, the temperature of the gas circulating through the second line 40 remains strictly lower than the temperature of the gas circulating through the first line 10. The junction between the second line 40 and the first
 15 line 10 upstream of the phase separator 36, considering the direction of fluid circulation, i.e., between the gaseous headspace and the phase separator 36, allows the gas in the liquid state circulating in the second line 40 to be distributed to the first line 10.

[0052] It should be noted that the second line 40 may be provided with a non-return valve, not shown here, to prevent gas from passing from the first line 10 towards the second line
 20 40.

[0053] The meeting of the gas in the liquid state circulating in the second line 40 with the gas in the vapor state circulating in the first line 10 generates an expansion phenomenon, also referred to as "flash", of the gas in the liquid state which, on contact with a hotter gas, vaporizes and allows to lower the temperature of the gas in the vapor state contained in the
 25 second line 40.

[0054] This cooling of the gas circulating in the vapor state in the first line 10 is controlled by a monitoring unit 44. In the embodiment shown, the monitoring unit 44 is configured to give an operating indication and/or control the operation of the pumping member 42 so that at least the circulation of the gas in the liquid state in the second line 40 may be controlled
 30 by the monitoring unit 44. It should be noted that by "giving an operating indication" is meant that the monitoring unit 44 is able to generate a signal or transmit an information to the operator so that the latter himself controls the pumping member 42 in accordance with the information transmitted by the monitoring unit 44.

[0055] The monitoring unit 44 is thus connected, for example electrically, at least to the
 35 pumping member 42, so as to activate or stop it. The monitoring unit 44 is also connected,

for example electrically, to the temperature sensor 64 located at the inlet to the compression device 20 and/or a temperature sensor 66 located in the headspace of the tank and/or to a temperature sensor 68 in a duct of the first line 10 and/or to a flow meter 46 and/or to the valves 32 and 34. The monitoring unit 44 thus receives information from the temperature sensor 64 located at the inlet of the compression device 20 and/or from the temperature sensor 66 located in the headspace of the tank and/or from the temperature detector 68 in the duct of the first line 10 and/or from the flow meter 46, and activates or deactivates the pumping member 42, depending on a strategy implemented by the method covered by the invention.

10 [0056] Figures 2 and 3 show in more detail the management of gas circulation within the gas treatment system 2 as monitored by the monitoring unit 44. More specifically, Figure 2 shows the gas treatment system 2 when the pumping member 42 does not generate a circulation of gas in the liquid state in the second line 40 and Figure 3 shows the gas treatment system 2 when the pumping member 42 generates a circulation of the gas in the liquid state contained in the storage tank 6 in the second line 40.

[0057] The present invention integrates the control of the pumping member 42 by the monitoring unit 44 within a method for treating a gas by the gas treatment system 2.

[0058] The treatment method implements a first step during which the monitoring unit 44 collects at least one data relating to the temperature of the gas in the vapor state determined at the inlet of the compression device 20 and gives an operating indication and/or controls the pumping member 42 as a function of said data relating to the temperature of the gas in the vapor state determined at the inlet of the compression device. To this end, the first line 10 may be provided, for example, with a temperature sensor 64 to measure or determine *in situ* the temperature of the gas in the vapor state circulating in the first line 10, and more specifically at the inlet to the compression device 20. Alternatively, the temperature sensor 66 may be associated with the first or second compressor 24, 30. Such a temperature sensor 66 is immersed in the vapor state gas circulating in the first line 10. Advantageously, it is located at the inlet to the compression device 20.

[0059] The treatment method also implements a second step during which the monitoring unit 44 determines a threshold temperature value and a third step during which the monitoring unit 44 compares the data relating to the temperature of the gas in the vapor state at the inlet of the compression device with the threshold temperature value and gives an operating indication and/or controls the pumping member 42 as a function of said comparison.

[0060] The threshold temperature value is a variable temperature which takes into account at least one parameter. In the embodiment shown, the threshold temperature value is a function of a plurality of parameters which influence each other.

5 [0061] In the embodiment shown, the pumping member 42 is able to assume a first operating state wherein the pumping member 42 generates the circulation of the gas in the liquid state in the second line 40, as seen in Figure 3, and a second operating state wherein the pumping member 42 does not generate circulation of the gas in the liquid state in the second line 40, as seen in Figure 2.

10 [0062] It is understood that in the embodiment shown, the pumping member 42 is an on/off type pump. Of course, in an alternative embodiment of the invention, the pumping member 42 may be completely controlled by the monitoring unit 44 so as to adapt the flow rate of gas in the liquid state circulating in the second line 40 according to the need to cool the gas in the vapor state circulating in the first line 10.

15 [0063] The passage from one of said operating states to the other of the pumping member 42 is controlled by the monitoring unit 44 in such a way that if the temperature of the gas in the vapor state circulating in the first line 10 and measured at the inlet of the compression device 20 is greater than the threshold temperature value, then the monitoring unit 44 gives an operating indication and/or drives the pumping member 42 so that the latter is in its first operating state. Conversely, if the temperature of the gas in the vapor state circulating in
20 the first line 10 and measured at the inlet of the compression device 20 is lower than the threshold temperature value, then the monitoring unit gives an operating indication and/or controls the pumping member 42 so that it is in its second operating state, the latter preventing the generation of calories transmitted to the natural gas in the liquid state.

25 [0064] It is understood from the above that during the third step of the gas treatment method, the monitoring unit 44 compares the temperature of the gas at the inlet to the compression device 20 with the threshold temperature value and gives an operating indication and/or controls the pumping member 42 so as to cause it to pass from one of said operating states to the other.

30 [0065] As mentioned previously, the threshold temperature value is determined by the monitoring unit 44. This threshold temperature value is evolutionary, i.e., the threshold temperature value is not defined by a given temperature value but by a temperature value that evolves according to the parameters and/or conditions wherein the LNG is found.

35 [0066] In the embodiment shown, the monitoring unit 44 is configured to collect data relating to the temperature of the gas present in the gaseous headspace 8 during an additional step of the treatment method. By collecting this data, the monitoring unit 44 is able to determine

the temperature of the NBOG and thus the temperature of the gas in the vapor state circulating in the first line 10. To this end, the gaseous headspace 8 of the storage tank 6 is provided, for example, with a temperature sensor 66 capable of collecting data relating to the temperature of the gas present in the gaseous headspace 8 and communicating them with the monitoring unit 44. Also, depending on the temperature of the gas present in the gaseous headspace 8, the monitoring unit 44 may adapt the threshold temperature value so that the gas in the vapor state at the inlet of the compression device 20 is at a temperature of at most -110°C .

[0067] The monitoring unit 44 is able to collect information relating to the flow rate of gas in the vapor state circulating in the first line 10 between the phase separator 36 and the compression device 20 during an additional step of the treatment method. This data is collected by a flow meter 46 which measures the flow speed of the gas in the vapor state between the phase separator 36 and the compression device 20. The greater the flow rate of the gas circulating in the first line 10, the lower the temperature of the gas in the vapor state circulating in the first line 10. Depending on the gas flow rate measured, the monitoring unit 44 modulates the threshold temperature value so that the gas in the vapor state at the inlet of the compression device 20 is at a temperature of no more than -110°C . When this flow rate is high, the temperature of the gas in the vapor state at the inlet of the compression device drops, which allows to interrupt the operation of the pumping member 42.

[0068] A monitoring unit 44 collects data relating to the movement of the gas contained in the liquid state in the storage tank 6 during an additional step of the treatment method. This data allows the monitoring unit 44 to determine the quantity of NBOG generated in the storage tank 6 by these movements of the gas contained in the liquid state in the storage tank 6. The greater the volume of NBOG generated in the storage tank 6, the greater the volume of gas compressed by the compression device 20. Also, the greater the volume of gas in the vapor state, the lower the temperature of the latter. In this way, the control of the pumping member 42 and/or the operating indication of the pumping member 42 are adapted to the volume of gas in the vapor state generated in the gaseous headspace 8 of the storage tank 6. More specifically, when the quantity of NBOG generated in the storage tank 6 is large, the temperature of the NBOG at the inlet to the compression device 20 is sufficiently low to avoid having to activate the pumping member 42.

[0069] It should be noted that the monitoring unit 44 is also able to control the first valve 32 and the second valve 34 so as to manage the redundancy between the first compressor 24 and the second compressor 30.

[0070] The first line 10 is formed by a duct wherein the gas in the vapor state is able to move from the gaseous headspace 8 to the compression device 20. This duct may be subject to external temperature stresses because it circulates on the deck of the vessel. Its temperature then varies according to these external constraints.

5 [0071] The monitoring unit 44 is configured to collect at least one data relating to the temperature of this duct forming the first line so as to adapt the threshold temperature value as a function of the temperature of said duct during an additional step in the treatment method. The temperature of the gas in vapor state circulating in the first line 10 varies as a function of the temperature of said duct. A temperature sensor 68 is placed against the duct
10 to measure its surface temperature. More specifically, the higher the temperature of the duct, the higher the temperature of the gas circulating in said duct, which requires the activation of the pumping member 42. Conversely, if the temperature of the duct making up the first line drops, the pumping member 42 may be switched off.

[0072] Figure 4 shows the floating structure 4 comprising the storage tank 6, which is
15 watertight and thermally insulated. It is generally prismatic in shape and is mounted in a double hull 46 of the floating structure 4, which may be a vessel or a floating platform. A wall of the storage tank 6 comprises a primary sealing membrane configured to be in contact with a liquefied gas, in this case LNG, contained in the storage tank 6, a secondary sealing membrane arranged between the primary sealing membrane and the double hull 46 of the
20 floating structure 4, and two thermally insulating barriers arranged respectively between the primary sealing membrane and the secondary sealing membrane and between the secondary sealing membrane and the double hull 46. In a simplified version, the floating structure 4 comprises a simple hull.

[0073] Loading/unloading pipes 48 arranged on an upper deck of the floating structure 4
25 may be connected, by means of suitable connectors, to a storage terminal 50 for transferring a cargo of liquefied gas and/or gas resulting from the evaporation of liquefied gas from or towards the storage tank 6.

[0074] Figure 4 also illustrates a storage terminal 50 comprising a loading and/or unloading station 52, a subsea duct 54 and an onshore installation 56. The loading and/or unloading
30 station 52 is a fixed offshore installation comprising a movable arm 58 and a tower supporting the movable arm 58. The movable arm 58 carries a bundle of insulated flexible hoses 60 that may be connected to the loading/unloading pipes 48. The movable arm 58 may be oriented to adapt to any size of floating structure 4. A connecting duct (not shown) extends inside the tower. The loading and/or unloading station 52 allows the floating
35 structure 4 to be loaded and/or unloaded from or towards the storage terminal 50, which

comprises tanks for storing liquefied gas and/or the gas resulting from the evaporation of the liquefied gas, as well as connecting ducts 62 connected by the subsea duct 54 to the loading and/or unloading station 52. The submarine duct 54 allows the transfer of the liquefied gas and/or the gas resulting from the evaporation of the liquefied gas between the loading and/or unloading station 52 and the floating structure 4 over a long distance, for example five kilometers, which allows to keep the floating structure 4 at a great distance from the coast during the loading and/or unloading operations.

[0075] In order to generate the pressure necessary for transferring the liquefied gas and/or the gas resulting from evaporation of the liquefied gas, pumps on board the floating structure 4 and/or pumps equipping the onshore installation 56 and/or pumps equipping the loading and unloading station 52 are implemented.

[0076] The examples have been described for a floating structure 4; however, they are also applicable to a structure on land.

[0077] The present invention achieves its stated aim by proposing a gas treatment system which allows to control the operation of a pumping member as a function of the cooling requirements of the gas admitted to the compression device, so as to optimize the energy balance during a voyage of the vessel and limit the operational losses of gas.

[0078] The present invention is not, however, limited to the means and configurations described and illustrated herein and extends equally to any equivalent means and configurations and to any technically operative combination of such means.

CLAIMS

1. A gas treatment system (2) comprising at least a first line (10) configured to ensure the circulation of a gas in a vapor state contained in a storage tank (6) and a second line
5 (40) configured to ensure the circulation of at least part of said gas contained in a liquid state in the storage tank (6), the first line (10) being configured to connect at least one gaseous headspace (8) of said storage tank (6) to a gas-consuming apparatus (12) and comprising at least one compression device (20) configured to supply the gas-consuming apparatus (12) with gas and a phase separator (36) arranged between the gaseous
10 headspace (8) and the compression device (20), the second line (40) comprising at least one pumping member (42) configured to supply the second line (40) with gas in the liquid state coming from the storage tank (6), said second line extending at least between said pumping member (42) and the first line (10), the second line (40) being fluidly connected to the first line (10) between the gaseous headspace (8) and the phase separator (36), the
15 second line (40) being configured to deliver gas in the liquid state into the first line (10) so as to lower the temperature of the gas in the vapor state circulating in the first line (10), characterized in that the gas treatment system (2) comprises a monitoring unit (44) which gives an operating indication and/or controls the operation of the pumping member (42) according to at least one temperature of the gas in the vapor state that is determined at the
20 inlet of the compression device (20).
2. The gas treatment system (2) according to claim 1, wherein the compression device (20) is a compression device (20) comprising at most two compression stages.
- 25 3. The gas treatment system (2) according to any one of claims 1 and 2, wherein the pumping member (42) is configured to assume at least a first operating state wherein the pumping member (42) generates the circulation of the gas in the liquid state in the second line (40) and to assume a second operating state wherein the pumping member (42) does not generate circulation of the gas in the liquid state in the second line (40), the monitoring
30 unit (44) being able to switch the pumping member (42) from one of said operating states to the other.
4. The gas treatment system (2) according to claim 3, wherein the monitoring unit (44) is able to define a threshold temperature value, the pumping member (42) being in its first
35 operating state when the temperature of the gas determined at the inlet of the compression

device (20) is greater than the threshold temperature value, the pumping member (42) being in its second operating state when the temperature of the gas determined at the inlet of the compression device (20) is less than the threshold temperature value.

- 5 5. The gas treatment system (2) according to claim 4, wherein the threshold temperature value is variable.
6. The gas treatment system (2) according to any one of claims 4 and 5, wherein the threshold temperature value is a function of at least the temperature of the gas present in
10 the gaseous headspace (8) of the storage tank (6).
7. The gas treatment system (2) according to any one of claims 4 to 6, wherein the threshold temperature value is a function of at least the flow rate of gas circulating in the first line (10) between the phase separator (36) and the compression device (20).
15
8. The gas treatment system (2) according to any one of claims 4 to 7, wherein the threshold temperature value is a function at least of the movement of the gas in the liquid state contained in the storage tank (6).
- 20 9. The gas treatment system (2) according to any one of claims 4 to 8, wherein the threshold temperature value is a function of at least one temperature of at least one duct forming the first line (10).
10. A gas treatment assembly comprising a storage tank (6) and a gas treatment system
25 (2) according to any one of claims 1 to 9, wherein the pumping member (42) is immersed in the gas contained in the liquid state in the storage tank (6).
11. A floating structure (4) comprising a gas treatment system (2) according to any one of claims 1 to 9 or a gas treatment assembly according to claim 10.
30
12. A method for treating a gas by a gas treatment system (2) according to any one of claims 1 to 9, the treatment method implementing at least:
 - a first step during which the monitoring unit (44) collects at least one data relating to the temperature of the gas in the vapor state determined at the inlet of the compression
35 device (20) and gives an operating indication and/or controls the pumping member (42)

as a function of said data relating to the temperature of the gas in the vapor state determined at the inlet of the compression device (20).

13. The treatment method according to claim 12 in combination with claim 4,
5 implementing at least:

- a second step during which the monitoring unit (44) determines a threshold temperature value,
 - a third step during which the monitoring unit (44) compares the data with the threshold temperature value and gives an operating indication and/or controls the pumping member (42) as a function of said comparison.
- 10

14. The treatment method according to claim 13, wherein during the third step, if the data relating to the temperature of the gas in the vapor state determined at the inlet of the compression device (20) is greater than the threshold temperature value, then the
15 monitoring unit (44) gives an operating indication and/or controls the pumping member (42) so that the pumping member (42) is in its first operating state, and if the data relating to the temperature of the gas in the vapor state determined at the inlet of the compression device (20) is less than the threshold temperature value, then the monitoring unit (44) gives an operating indication and/or controls the pumping member (42) so that the pumping member
20 (42) is in its second operating state.

15. The treatment method according to any one of claims 13 and 14, implementing at least one additional step during which the monitoring unit (44) collects at least one data relating to the temperature of the gas in the vapor state present in the gaseous headspace
25 (8) of the storage tank (6) in order to determine the threshold temperature value.

16. The treatment method according to any one of claims 13 to 15, implementing at least one additional step during which the monitoring unit (44) collects at least one data relating to the flow rate of gas in the vapor state circulating in the first line (10) between the
30 phase separator (36) and the compression device (20) in order to determine the threshold temperature value.

17. The treatment method according to any one of claims 13 to 16, implementing at least one additional step during which the monitoring unit (44) collects at least one data

relating to the temperature of at least one duct forming the first line (10) in order to determine the threshold temperature value.