

【DESCRIPTION】**【Invention Title】****SYSTEM AND METHOD FOR PROCESSING BOIL-OFF GAS****【Technical Field】**

[1] The present invention relates to a system and method for processing boil-off gas, and more particularly, to a system and method for processing boil-off gas, which can compress boil-off gas generated in an LNG storage tank to high pressure and supply the compressed boil-off gas downstream of a regasification line such that the boil-off gas is supplied to land along with regasified natural gas while supplying natural gas to land through the regasification line for regasifying LNG stored in the LNG storage tank.

【Background Art】

[2] Liquefied natural gas (hereinafter "LNG") is a colorless and transparent liquid obtained by cooling natural gas mainly composed of methane to about -162°C and has a volume of about 1/600 that of natural gas. Thus, natural gas can be efficiently transported by liquefying the natural gas into LNG.

[3] Since natural gas is liquefied at an extremely low temperature of -163°C at atmospheric pressure, LNG can evaporate even at a temperature slightly higher than -163°C at atmospheric pressure. Although an LNG storage tank of LNG carriers, LNG-FPSOs, RVs, and the like is thermally insulated, LNG naturally evaporates in the LNG storage tank due to heat continuously transferred to the LNG storage tank from outside. As a result, boil-off gas (BOG) is generated in the LNG storage tank.

[4] Generation of BOG results in LNG loss and contributes to reduction in transportation efficiency. In addition, when BOG accumulates in an LNG storage tank, there is a danger of

explosion due to excessive pressure increase in the LNG storage tank. Thus, various methods have been studied to process BOG generated in an LNG storage tank.

[5] Recently, in order to process BOG, there have been proposed a method in which BOG is reliquefied and returned to a storage tank, a method in which BOG is used as an energy source for a vessel engine, and the like. In addition, there has been proposed a method in which surplus BOG is burned in a gas combustion unit (GCU).

【Disclosure】

【Technical Problem】

[6] It is an aspect of the present invention to provide a system and method for processing boil-off gas, which can process BOG generated in a storage tank of a vessel or a marine structure such as LNG-RVs and LNG-FSRUs in an effective and safe manner.

【Technical Solution】

[7] In accordance with one aspect of the present invention, there is provided a BOG processing system for processing BOG generated in an LNG storage tank of a vessel or a marine structure, including:

[8] a regasification line for regasifying LNG stored in the LNG storage tank and supplying natural gas; and

[9] a high-pressure compression line for compressing BOG generated in the LNG storage tank to high pressure and supplying the compressed BOG downstream of the regasification line.

[10] The BOG processing system may further include: a recondenser provided to the regasification line and receiving supercooled LNG from the LNG storage tank; and a low-pressure condensation line for compressing BOG generated in the LNG storage tank to low

pressure and supplying the compressed BOG to the recondenser such that the BOG is recondensed through heat exchange with the supercooled LNG.

[11] The BOG processing system may further include: a high-pressure pump provided to the regasification line and compressing LNG supplied from the recondenser; a vaporizer provided to the regasification line and vaporizing LNG compressed by the high-pressure pump; and a high-pressure compressor provided to the high-pressure compression line and compressing BOG supplied from the LNG storage tank to high pressure.

[12] The BOG compressed to high pressure by the compressor may be supplied downstream of the vaporizer on the regasification line.

[13] The BOG processing system may further include: a low-pressure compressor provided to the low-pressure condensation line and compressing BOG supplied from the LNG storage tank to low pressure and supplying the compressed BOG to the recondenser; and an LNG supply pump provided to the LNG storage tank and pumping supercooled LNG to the recondenser.

[14] The BOG processing system may further include: a fuel supply line for supplying the compressed BOG from the high-pressure compression line and the low-pressure condensation line to gas consumption units including gas engines, gas combustion units (GCUs), and boilers of the vessel or the marine structure.

[15] The vessel or the marine structure may include an LNG-regasification vessel and an LNG-floating storage regasification unit regasifying LNG and supplying natural gas to land.

[16] In accordance with another aspect of the present invention, there is provided a BOG processing method for processing BOG generated in an LNG storage tank of a vessel or a marine structure, including:

[17] compressing BOG generated in the LNG storage tank to high pressure and supplying the compressed BOG to land along with regasified natural gas while regasifying LNG stored

in the LNG storage tank to supply natural gas to land.

[18] The BOG processing method may further include: compressing the boil-off gas generated in the LNG storage tank to low pressure and mixing the compressed boil-off gas with the LNG to be regasified such that the compressed boil-off gas is recondensed.

[19] The BOG processing method may further include: compressing boil-off gas remaining after being recondensed by cold heat from the LNG to high pressure and supplying the compressed boil-off gas to land along with the regasified natural gas, while compressing the boil-off gas generated in the LNG storage tank to low pressure and mixing the compressed boil-off gas with the LNG to be regasified such that the compressed BOG is recondensed.

【Advantageous Effects】

[20] The BOG processing system according to the present invention can compress BOG generated in an LNG storage tank to high pressure and supply the compressed BOG downstream of a regasification line such that the BOG can be supplied to land along with regasified LNG while supplying natural gas to land through the regasification line for regasifying LNG stored in the LNG storage tank.

[21] In addition, the BOG processing system according to the present invention may compress BOG to low pressure and recondense the BOG using cold heat from supercooled LNG to be regasified. Here, when LNG to be regasified is small in quantity, BOG may be compressed to high pressure and supplied to land through the regasification line, whereby BOG can be processed more effectively.

[22] Further, the BOG processing system according to the present invention can prevent pressure rise in a storage tank to secure safety and reduce wasted BOG because it is not necessary to supply surplus BOG to GCUs.

【Description of Drawings】

[23] Fig. 1 is a schematic view of a typical BOG processing system.

[24] Fig. 2 is a schematic view of a BOG processing system according to one exemplary embodiment of the present invention.

【Best Mode】

[25] The above and other aspects, features, and advantages of the present invention will become apparent from the detailed description of the following embodiments in conjunction with the accompanying drawings.

[26] Hereinafter, exemplary embodiments of the present invention will be described in detail with reference to the accompanying drawings. It should be noted that like components will be denoted by like reference numerals throughout the specification and the accompanying drawings.

[27] A BOG processing system according to the present invention may be used in a vessel or a marine structure which is provided with an LNG storage tank, in which BOG is generated, for example, LNG-regasification vessels (LNG-RVs) and LNG-floating storage regasification units (LNG-FSRUs) for regasifying LNG and supplying natural gas to land.

[28] It is known that, for example, a 150,000 m³ vessel has a BOG rate of 3 ton/h to 4 ton/h when fully loaded and a BOG rate of 0.3 ton/h to 0.4 ton/h under ballast conditions, although the BOG rate varies depending upon capacity of the storage tank and external temperature. Recently, as a boil off rate (BOR) is reduced due to improvement in insulation performance of a vessel, the BOG rate is gradually decreasing.

[29] However, there is a need for a BOG processing system which can secure safety of a storage tank and thus safety of a vessel or a marine structure and efficiently prevent waste of natural gas, since a large amount of BOG is still generated in the storage tank.

[30] Fig. 1 is a schematic view of a typical BOG processing system.

[31] Referring to Fig. 1, the BOG processing system is used in a vessel or a marine structure such as LNG-RVs or LNG-FSRUs which supply natural gas to land through a pump P pumping LNG from a storage tank T to a recondenser 20 and a pump 30 compressing LNG to high pressure and a vaporizer 40. In the BOG processing system, BOG generated in the storage tank is compressed to low pressure by a compressor 10 and supplied to the recondenser 20. Then, the BOG is recondensed in the recondenser 20 by cold heat from supercooled LNG supplied from the storage tank T by a pump P.

[32] Such a BOG processing system in which BOG is recondensed by cold heat from LNG has a problem in that sufficient cold heat cannot be transferred to BOG when LNG to be regasified is small in quantity.

[33] Fig. 2 is a schematic view of a BOG processing system according to one exemplary embodiment of the present invention having been conceived to solve such a problem in the art.

[34] A BOG processing system shown in Fig. 2 is configured to process BOG generated in an LNG storage tank T of a vessel or a marine structure and includes a regasification line L1 for regasifying LNG stored in the LNG storage tank T to supply natural gas, wherein the regasification line L1 is provided with a high-pressure pump 200 for compressing LNG supplied from a recondenser 100 and a vaporizer 300 for vaporizing LNG compressed by the high-pressure pump 200 such that natural gas regasified under high pressure through the high-pressure pump 200 and the vaporizer 300 can be supplied to land GS.

[35] In this embodiment, the BOG processing system includes a high-pressure compression line L2 for compressing BOG generated in the LNG storage tank T to high pressure and supplying the BOG downstream of the regasification line L1.

[36] The high-pressure compression line L2 is provided with a high-pressure compressor

400 for compressing BOG supplied from the LNG storage tank T to high pressure, and the BOG compressed to high pressure by the high-pressure compressor 400 is supplied downstream of the vaporizer 300 on the regasification line L1.

[37] The high-pressure compressor 400 may compress BOG to a pressure at which natural gas is supplied to land through the high-pressure pump 200 and the vaporizer 300.

[38] Since BOG is directly compressed and then supplied to land along with natural gas regasified from LNG, as described above, a large amount of BOG can be efficiently processed even when supercooled LNG for reliquefying BOG is small in quantity.

[39] In addition, since BOG is increased in temperature while being compressed by the high-pressure compressor 400, regasified natural gas can be further heated by supplying the BOG downstream of the vaporizer 300, thereby reducing heat source demand of the vaporizer 300.

[40] In this embodiment, the regasification line L1 is provided with a recondenser 100 for receiving supercooled LNG from the LNG storage tank T, and the BOG processing system includes a low-pressure condensation line L3 for compressing BOG generated in the LNG storage tank T to low pressure and supplying the BOG to the recondenser 100 such that low-pressure compressed BOG introduced into the recondenser 100 can be condensed through heat-exchange with the supercooled LNG.

[41] The low-pressure condensation line L3 is provided with a low-pressure compressor 500 for compressing BOG supplied from the LNG storage tank T to low pressure and supplying the BOG to the recondenser 100, and the LNG storage tank T is provided with an LNG supply pump P for pumping supercooled LNG to the recondenser 100.

[42] Processing of BOG through the high-pressure compression line L2 and processing of BOG through the low-pressure condensation line L3 may be performed at the same time or may be selectively performed depending upon the BOG rate, the amount of LNG to be

regasified, and the like.

[43] For example, when LNG to be regasified is large in quantity and thus can supply sufficient cold heat for recondensation of compressed BOG, the BOG may be recondensed through the low-pressure condensation line L3, whereas when LNG to be regasified is small in quantity, the BOG may be compressed through the high-pressure compression line L2 to be directly supplied to land along with regasified natural gas.

[44] Particularly, since the high pressure compressor 400 requires high power consumption to compress gaseous BOG to high pressure, BOG generated in the LNG storage tank may be compressed to low pressure and mixed with LNG that will be regasified by the recondenser 100 to be recondensed by cold heat from supercooled LNG, and BOG remaining after being recondensed by cold heat from the LNG may be compressed by the high-pressure compressor 400 and supplied downstream of the vaporizer on the regasification line to be supplied to land along with natural gas, thereby effectively processing BOG while reducing power consumption.

[45] BOG may be compressed to a pressure of 50 bar to 100 bar by the high-pressure pump 200 and the high pressure compressor 400 on the high-pressure compression line L2, whereas BOG may be compressed to a pressure of 2 bar to 10 bar by the low-pressure compressor 500 on the low-pressure condensation line L3.

[46] The BOG processing system may further include a fuel supply line (not shown) for supplying the compressed BOG from the high-pressure compression line L2 and the low-pressure condensation line L3 to gas consumption units C1, C2, C3 including gas engines, gas combustion units (GCUs), and boilers of a vessel or a marine structure, such that BOG remaining after being processed through the high-pressure compression line L2 and the low-pressure condensation line L3 can be supplied to the gas consumption units C1, C2, C3 of a vessel or a marine structure.

[47] The gas consumption units C1, C2, C3 may be gas engines such as dual fuel diesel electric (DFDE) engines, tri fuel diesel electric (TFDE) engines, and ME-GI engines.

[48] Another aspect of the present invention relates to a BOG processing method for processing BOG generated in an LNG storage tank T of a vessel or a marine structure, including: compressing BOG generated in the LNG storage tank T to high pressure and supplying the BOG to land along with regasified natural gas while regasifying LNG stored in the LNG storage tank T to supply natural gas to land.

[49] The BOG generated in the LNG storage tank T may be compressed to low pressure and mixed with LNG that will be regasified to be recondensed.

[50] According to the present invention, it is possible to provide a BOG processing system which can process a large amount of BOG even when the amount of LNG to be regasified or the BOG rate changes and to reduce wasted BOG because it is not necessary to supply surplus BOG to GCUs. In addition, according to the present invention, it is possible to provide a BOG processing system which can effectively process BOG and thus can prevent pressure rise in a storage tank, thereby securing safety of the storage tank and thus safety of a vessel or a marine structure.

[51] Although some embodiments have been described herein, it should be understood that the present invention is not limited thereto and various modifications, variations, and alterations can be made by those skilled in the art without departing from the spirit and scope of the present invention. Therefore, the scope of the invention should be limited only by the accompanying claims and equivalents thereof.

【CLAIMS】**【Claim 1】**

A boil-off gas processing system for processing boil-off gas generated in an LNG storage tank of a vessel or a marine structure, comprising:

a regasification line for regasifying LNG stored in the LNG storage tank and supplying natural gas; and

a high-pressure compression line for compressing boil-off gas generated in the LNG storage tank to high pressure and supplying the compressed boil-off gas downstream of the regasification line.

【Claim 2】

The boil-off gas processing system according to claim 1, further comprising:

a recondenser provided to the regasification line and receiving supercooled LNG from the LNG storage tank; and

a low-pressure condensation line for compressing boil-off gas generated in the LNG storage tank to low pressure and supplying the boil-off gas to the recondenser such that the boil-off gas is recondensed through heat exchange with the supercooled LNG.

【Claim 3】

The boil-off gas processing system according to claim 2, further comprising:

a high-pressure pump provided to the regasification line and compressing LNG supplied from the recondenser;

a vaporizer provided to the regasification line and vaporizing LNG compressed by the high-pressure pump; and

a high pressure compressor provided to the high-pressure compression line and compressing boil-off gas supplied from the LNG storage tank to high pressure.

【Claim 4】

The boil-off gas processing system according to claim 3, wherein the boil-off gas compressed to high pressure by the compressor is supplied downstream of the vaporizer on the regasification line.

【Claim 5】

The boil-off gas processing system according to claim 2, further comprising:

a low-pressure compressor provided to the low-pressure condensation line and compressing the boil-off gas supplied from the LNG storage tank to low pressure and supplying the boil-off gas to the recondenser; and

an LNG supply pump provided to the LNG storage tank and pumping supercooled LNG to the recondenser.

【Claim 6】

The boil-off gas processing system according to claim 2, further comprising:

a fuel supply line for supplying the compressed boil-off gas from the high-pressure compression line and the low-pressure condensation line to gas consumption units comprising gas engines, gas combustion units (GCUs), and boilers of the vessel or the marine structure.

【Claim 7】

The boil-off gas processing system according to claim 1, wherein the vessel or the

marine structure comprises an LNG-regasification vessel (LNG-RV) and an LNG-floating storage regasification unit (LNG-FSRU) regasifying LNG and supplying natural gas to land.

【Claim 8】

A boil-off gas processing method for processing boil-off gas generated in an LNG storage tank of a vessel or a marine structure, comprising:

compressing boil-off gas generated in the LNG storage tank to high temperature and supplying the compressed boil-off gas to land along with regasified natural gas while regasifying LNG stored in the LNG storage tank to supply natural gas to land.

【Claim 9】

The boil-off gas processing method according to claim 8, further comprising:

compressing the boil-off gas generated in the LNG storage tank to low pressure and mixing the compressed boil-off gas with the LNG to be regasified such that the compressed boil-off gas is recondensed.

【Claim 10】

The boil-off gas processing method according to claim 9, further comprising:

compressing boil-off gas remaining after being recondensed by cold heat from the LNG to high pressure and supplying the compressed boil-off gas to land along with the regasified natural gas, while compressing the boil-off gas generated in the LNG storage tank to low pressure and mixing the compressed boil-off gas with the LNG to be regasified such that the compressed BOG is recondensed.