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(71) Applicant: **Kawasaki Jukogyo Kabushiki Kaisha**
Kobe-shi, Hyogo 650-8670 (JP)

(72) Inventors:
- **HOSONO, Takamichi**
  Hyogo 673-8666 (JP)
- **YOSHIZAWA, Katsuhiro**
  Hyogo 673-8666 (JP)
- **IWASAKI, Hidekazu**
  Hyogo 673-8666 (JP)
- **NISHIMURA, Motohiko**
  Hyogo 673-8666 (JP)
- **HIGASHIDA, Masanori**
  Hyogo 650-8670 (JP)
- **NOGAMI, Tetsuo**
  Hyogo 650-8670 (JP)

(74) Representative: **Witte, Weller & Partner**
Patentanwälte mbB
Postfach 10 54 62
70047 Stuttgart (DE)

(54) CLEANING/COOLING DEVICE, EGR UNIT AND ENGINE SYSTEM

(57) A cleaning/cooling device (31) is a device constituting a part of an EGR unit (30) and includes: a cleaning portion (33) configured to clean an exhaust gas by using a cleaning liquid; and a cooling portion (34) provided adjacent to the cleaning portion (33) and configured to cool the exhaust gas cleaned by the cleaning portion (33). The cleaning portion (33) includes a liquid area (37) in which the cleaning liquid used for cleaning is pooled. The cooling portion (34) includes a liquid area (41) which receives condensed water generated by cooling the exhaust gas. The liquid area (37) of the cleaning portion (33) and the liquid area (41) of the cooling portion (34) are directly connected to each other.

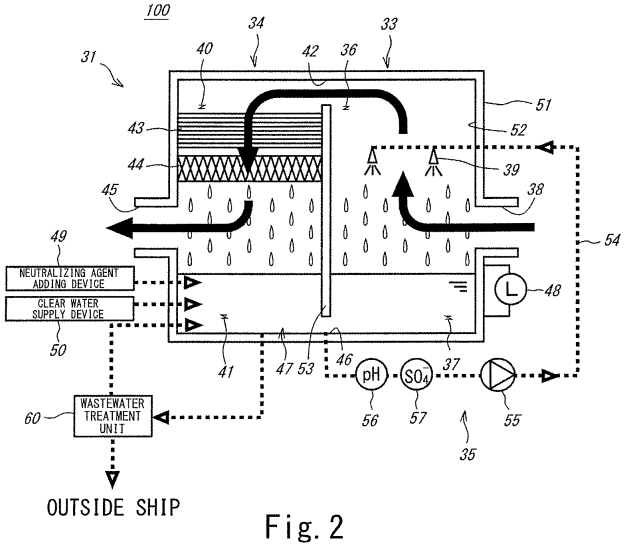

Fig. 2

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Description

Technical Field

[0001] The present invention relates to a cleaning/cooling device which cleans and cools an exhaust gas.

Background Art

[0002] Known as a method of reducing the amount of nitrogen oxide (NOx) discharged from an engine is exhaust gas recirculation (EGR) of returning a part of the exhaust gas to the engine. By returning a part of the exhaust gas to the engine, combustion is performed in a state where oxygen concentration is low. As a result, a combustion temperature decreases, and this suppresses the generation of the NOx. Depending on a fuel to be used, the exhaust gas may contain a large amount of particulate matters (PM) and sulfur oxide (SOx). In such a case, the PM and the SOx need to be removed from the exhaust gas to be recirculated. To remove the PM and the SOx from the exhaust gas, a wet gas scrubber (scrubber) which removes the PM and the SOx by a cleaning liquid is effective (see a reference sign 15 of Fig. 2 in PTL 1).

[0003] In a case where the scrubber is provided in an EGR unit, a gas cooler may be provided downstream of the scrubber. The exhaust gas cleaned by the scrubber is in a saturated state and contains a large amount of moisture. Therefore, when the cleaned exhaust gas is cooled by the gas cooler, a large amount of moisture in the exhaust gas is discharged as condensed water. Thus, the moisture contained in the exhaust gas can be removed. Therefore, by providing the gas cooler as above, the moisture of the exhaust gas can be prevented from adhering to devices provided downstream of the gas cooler, and therefore, the corrosion of those devices and the like can be suppressed.

[0004] Typically, the cleaning liquid used by the scrubber and the condensed water generated by the gas cooler are discharged to and temporarily pooled in a surge tank provided separately. To reutilize the used cleaning liquid and the condensed water in the scrubber as the cleaning liquid, the used cleaning liquid and the condensed water are pooled in the surge tank. However, to reutilize the used cleaning liquid and the condensed water as the cleaning liquid, a neutralizing agent needs to be added to the surge tank or a pipe. The reason for this is as follows. When the cleaning liquid or the condensed water absorbs the SOx, a pH value of the cleaning liquid or the condensed water decreases, and the cleaning liquid or the condensed water turns acidic. If such a liquid of the low pH value is used as the cleaning liquid, a desulfurization reaction does not proceed, and therefore, the SOx cannot be efficiently removed. In contrast, if the pH value of the liquid pooled in the surge tank is made too high, salt sticks or CO_2 dissolves, so that the neutralizing agent needs to be further added. The concentration of the SOx in the exhaust gas changes depending on a load of the engine and an EGR ratio (a bypass ratio for an EGR line), and the pH value of the liquid pooled in the surge tank also changes in accordance with the concentration of the SOx. Therefore, to efficiently clean the exhaust gas, the pH value of the liquid pooled in the surge tank needs to be observed at all times, and an appropriate amount of neutralizing agent needs to be added in accordance with the pH value.

Citation List

Patent Literature

[0005] PTL 1: Japanese Laid-Open Patent Application Publication No. 2011-157959

Summary of Invention

Technical Problem

[0006] As described above, the pH value of the liquid in the surge tank is adjusted by the addition of the neutralizing agent. However, since the amount of cleaning liquid circulating in the EGR unit is extremely large in reality, a response reaction of the pH value is slow, and stabilizing the pH value within an ideal range is not easy.

[0007] In a case where the surge tank is arranged so as to be separated from the scrubber and the gas cooler, it is practically impossible to maintain the pressure in the surge tank at high pressure that is substantially equal to internal pressure of the EGR line, and the liquid in the surge tank is pooled under atmospheric pressure. In this case, to supply the liquid in the surge tank to the scrubber as the cleaning liquid, the pressure of the cleaning liquid which has decreased to the atmospheric pressure needs to be increased to pressure substantially equal to internal pressure of the scrubber. Therefore, a pump to be used increases in size, and power consumption of the pump increases.

[0008] Further, since the cleaning liquid and condensed water flowing into the surge tank are acidic, pipes and the like through which the cleaning liquid and the condensed water flow needs to have corrosion resistance, and this leads to an increase in manufacturing cost of an EGR system.

[0009] To stably supply the cleaning liquid to the scrubber, the capacity of the surge tank needs to be large. In a case where the EGR unit includes the surge tank, the EGR unit naturally has to include pipes and the like attached to the surge tank. To be specific, although the decrease in size of the EGR unit is desired, providing the surge tank is an obstruction for the decrease in size of the EGR unit.

[0010] The present invention was made under the above circumstances, and an object of the present invention is to configure an EGR unit not including a surge

tank.

Solution to Problem

[0011] A cleaning/cooling device according to an aspect of the present invention is a device constituting a part of an EGR unit and includes: a cleaning portion configured to clean an exhaust gas by using a cleaning liquid; and a cooling portion provided adjacent to the cleaning portion and configured to cool the exhaust gas cleaned by the cleaning portion, wherein: the cleaning portion includes a liquid area in which the cleaning liquid used for cleaning is pooled; the cooling portion includes a liquid area which receives condensed water generated by cooling the exhaust gas; and the liquid area of the cleaning portion and the liquid area of the cooling portion are directly connected to each other.

[0012] Herein, the phrase "directly connected to each other" denotes that the liquid areas are connected to each other without through a tank and does not include a case where the liquid areas are "indirectly connected to each other" through a tank. For example, the case where the liquid area of the cleaning portion and the liquid area of the cooling portion are "directly connected to each other" may denote: a case where the liquid area of the cleaning portion and the liquid area of the cooling portion are integrally formed as a single water pooling portion; a case where the liquid area of the cleaning portion and the liquid area of the cooling portion are connected to each other through a pipe; and a case where the liquid in the liquid area of the cleaning portion and the liquid in the liquid area of the cooling portion are directly moved to each other by a pump or the like. According to the above configuration, since the liquid area of the cleaning portion and the liquid area of the cooling portion are directly connected to each other, the condensation water generated in the cooling portion is not conveyed to another device but is used as the cleaning liquid. Therefore, the EGR unit including the cleaning/cooling device does not require a surge tank which pools the cleaning liquid.

[0013] The cleaning/cooling device may be configured such that: the cleaning portion includes a gas area through which the cleaned exhaust gas flows; the cooling portion includes a gas area through which the exhaust gas to be cooled flows; and the gas area of the cleaning portion and the gas area of the cooling portion are directly connected to each other. According to this configuration, since the cleaning portion and the cooling portion are directly connected to each other, the EGR unit can be further reduced in size.

[0014] The cleaning/cooling device may be configured such that the cleaning portion and the cooling portion are defined by an inner wall of an outer frame case and a dividing member which divides an internal space of the outer frame case. According to this configuration, the cleaning/cooling device can be configured to have an extremely simple structure.

[0015] The cleaning/cooling device may be configured such that: the gas area of the cleaning portion and the gas area of the cooling portion are directly connected to each other in a vicinity of an upper end of the dividing member; and the liquid area of the cleaning portion and the liquid area of the cooling portion are directly connected to each other in a vicinity of a lower end of the dividing member. According to this configuration, a space in the outer frame case can be used efficiently.

[0016] The cleaning/cooling device may be configured such that the dividing member has a plate shape. According to this configuration, the cleaning/cooling device can be configured to have a simpler structure.

[0017] The cleaning/cooling device may be configured such that the cleaning portion pumps up the cleaning liquid in the liquid area and injects the cleaning liquid to the exhaust gas.

[0018] The cleaning/cooling device may be configured such that the cleaning portion emits the exhaust gas to an inside of the cleaning liquid in the liquid area. According to this configuration, cleaning by a water pool method can be performed by efficiently utilizing the liquid area of the cleaning portion.

[0019] Further, an EGR unit according to another aspect of the present invention includes the above cleaning/cooling device, wherein the exhaust gas cleaned and cooled by the cleaning/cooling device is recirculated to an engine.

[0020] Further, an engine system according to yet another aspect of the present invention includes the above EGR unit.

Advantageous Effects of Invention

[0021] As above, since the EGR unit includes the above-described cleaning/cooling device, the EGR unit not including the surge tank can be configured.

Brief Description of Drawings

[0022]

Fig. 1 is a block diagram showing an engine system according to Embodiment 1.

Fig. 2 is a schematic diagram showing a cleaning/cooling device of the engine system.

Fig. 3 is a schematic diagram showing the cleaning/cooling device of the engine system according to Embodiment 2.

Description of Embodiments

[0023] Hereinafter, embodiments of the present invention will be explained in reference to the drawings. In the following description and the drawings, the same reference signs are used for the same or corresponding components, and a repetition of the same explanation is avoided.

Embodiment 1

[0024] First, Embodiment 1 will be explained in reference to Figs. 1 and 2.

Engine System

[0025] First, an engine system 100 according to the present embodiment will be explained. Fig. 1 is a block diagram showing the engine system 100. As shown in Fig. 1, the engine system 100 includes an engine 10, a turbocharger 20, and an EGR unit 30.

[0026] The engine 10 of the present embodiment is a propelling main engine for a ship and is a two-stroke diesel engine. A scavenging gas ("supply gas" in the case of the four-stroke engine) is supplied from the turbocharger 20 through a scavenging passage 11 to the engine 10. An exhaust gas discharged from the engine 10 is supplied through an exhaust passage 12 to the turbocharger 20. It should be noted that the engine 10 may be a four-stroke engine, a gas engine, or a gasoline engine. The engine 10 is not limited to an engine for a ship and may be an engine for a power generation facility.

[0027] The turbocharger 20 is a device which increases the pressure of air and supply the air to the engine 10. The turbocharger 20 includes a turbine portion 21 and a compressor portion 22. The exhaust gas discharged from the engine 10 is supplied to the turbine portion 21, and the turbine portion 21 rotates by energy of the exhaust gas. The turbine portion 21 and the compressor portion 22 are coupled to each other by a coupling shaft 23, and the compressor portion 22 rotates in accordance with the rotation of the turbine portion 21. When the compressor portion 22 rotates, the air (atmosphere) taken from outside is compressed, and the compressed air is supplied to the engine 10 as the scavenging gas.

[0028] The EGR unit 30 is a unit by which the exhaust gas discharged from the engine 10 is returned (recirculated) to the engine 10. The EGR unit 30 extracts the exhaust gas from the exhaust passage 12. The extracted exhaust gas is cleaned and cooled by a cleaning/cooling device 31 (described later in detail) and is then supplied to the scavenging passage 11. An EGR blower 32 is provided downstream of the cleaning/cooling device 31. The exhaust gas in the EGR unit 30 is supplied to the scavenging passage 11 by power of the EGR blower 32. As above, by supplying the exhaust gas (burnt gas) to the scavenging passage 11, the oxygen concentration of the scavenging gas supplied to the engine 10 decreases, and therefore, the amount of NOx discharged can be reduced.

Cleaning/cooling Device

[0029] Next, the cleaning/cooling device 31 constituting a part of the EGR unit 30 will be explained. Fig. 2 is a schematic diagram showing the cleaning/cooling device 31 according to the present embodiment. As shown in Fig. 2, the cleaning/cooling device 31 includes a cleaning portion 33, a cooling portion 34, and a circulation device 35.

[0030] The cleaning portion 33 is a portion which cleans the exhaust gas. The cleaning portion 33 includes a gas area 36 filled with the exhaust gas and a liquid area 37 filled with the cleaning liquid. A range of the gas area 36 and a range of the liquid area 37 are determined in accordance with the position of a liquid surface of the cleaning liquid. An inlet port 38 is formed in the gas area 36. The exhaust gas flows through the inlet port 38 into the cleaning portion 33. An injection nozzle 39 which injects the cleaning liquid is provided in the gas area 36. The exhaust gas is cleaned by the cleaning liquid injected from the injection nozzle 39. The cleaning liquid which has taken PM and SOx from the exhaust gas falls by its own weight to be pooled in the liquid area 37. A part of the cleaning liquid vaporizes to be absorbed by the exhaust gas. Thus, the exhaust gas becomes a saturated state.

[0031] The cooling portion 34 is a portion which cools the exhaust gas cleaned by the cleaning portion 33. By cooling the exhaust gas, the condensed water can be generated, and the moisture can be removed from the exhaust gas. The cooling portion 34 also includes a gas area 40 filled with the exhaust gas and a liquid area 41 filled with a liquid (condensation water and cleaning liquid). The gas area 40 of the cooling portion 34 and the gas area 36 of the cleaning portion 33 are directly connected to each other through a gas connecting port 42. The exhaust gas cleaned by the cleaning portion 33 flows from the gas area 36 of the cleaning portion 33 through the gas connecting port 42 into the gas area 40 of the cooling portion 34. A heat exchanger 43 and a mist catcher 44 are provided in the gas area 40 of the cooling portion 34. An outlet port 45 is formed in the gas area 40.

[0032] A cooling medium (seawater, for example) flows in the heat exchanger 43 of the cooling portion 34, and the heat exchange is performed between the cooling medium and the exhaust gas. The exhaust gas in the cooling portion 34 flows through the heat exchanger 43 to be cooled. Further, the mist catcher 44 catches the mist of the cleaning liquid in the exhaust gas having flowed through the heat exchanger 43. Finally, the exhaust gas flows through the outlet port 45 to be discharged from the cleaning/cooling device 31. The condensed water generated by cooling the exhaust gas and the cleaning liquid caught by the mist catcher 44 fall by their own weights, and the fallen condensation water and cleaning liquid are received by the liquid area 41.

[0033] The liquid area 41 of the cooling portion 34 and the liquid area 37 of the cleaning portion 33 are directly connected to each other through a liquid connecting port 46. Therefore, the liquid area 41 of the cooling portion 34 and the liquid area 37 of the cleaning portion 33 are integrally connected to each other under the liquid surface to form a water pooling portion 47. A liquid level of

the water pooling portion 47 is measured by a level meter 48 provided at the cleaning/cooling device 31. A part of the cleaning liquid of the water pooling portion 47 is discharged to a wastewater treatment unit 60 and is treated, that is, for example, foreign matters are removed by a centrifuge or the like. The part of the cleaning liquid treated by the wastewater treatment unit 60 is returned to the water pooling portion 47, and the rest of the cleaning liquid is discharged to outside (sea, for example). A neutralizing agent is added to the water pooling portion 47 from a neutralizing agent adding device 49, and clear water is supplied to the water pooling portion 47 from a clear water supply device 50.

[0034] The cleaning portion 33 and the cooling portion 34 are defined by: an inner wall 52 of an outer frame case 51; and a dividing member 53 which divides an internal space of the outer frame case 51. The shape of the outer frame case 51 and the shape of the dividing member 53 are not limited. For example, the outer frame case 51 has a shape similar to a rectangular solid, and the dividing member 53 has a plate shape. A leftward/rightward direction on the sheet of Fig. 2 is defined as a "first direction", and a direction perpendicular to the sheet of Fig. 2 is defined as a "second direction". The dividing member 53 of the present embodiment is located at a substantially center of the outer frame case 51 in the first direction and extends in the second direction. Both second direction end portions of the dividing member 53 contact the inner wall 52 of the outer frame case 51. In contrast, a gap is formed between an upper end of the dividing member 53 and the inner wall 52 of the outer frame case 51, and this gap constitutes the gas connecting port 42. Similarly, a gap is formed between a lower end of the dividing member 53 and the inner wall 52 of the outer frame case 51, and this gap constitutes the liquid connecting port 46.

[0035] The circulation device 35 is a device which pumps up the cleaning liquid in the water pooling portion 47 and supplies the cleaning liquid to the injection nozzle 39 of the cleaning portion 33. The circulation device 35 is mainly constituted by: a circulation pipe 54 connecting the water pooling portion 47 and the injection nozzle 39; and a circulating pump 55 disposed on the circulation pipe 54. A pH meter 56 and a SO_4 ion counter 57 are disposed on the circulation pipe 54. The cleaning/cooling device 31 controls the amount of neutralizing agent added from the neutralizing agent adding device 49, the amount of clear water supplied from the clear water supply device 50, and the amounts of cleaning liquid flowing into and flowing out from the wastewater treatment unit 60 based on measured values of the pH meter 56, the SO_4 ion counter 57, and the level meter 48 such that: the liquid level of the water pooling portion 47 is always located above an upper end portion of the liquid connecting port 46 connecting the liquid area 37 and the liquid area 41 (i.e., a case is prevented, in which the liquid surface of the cleaning liquid becomes lower than the upper end portion of the liquid connecting port 46, and a part of the exhaust gas in the gas area 36 of the cleaning portion 33 flows through the liquid connecting port 46 into the gas area 40 of the cooling portion 34 (a part of the exhaust gas in the gas area 36 of the cleaning portion 33 bypasses the heat exchanger 43 and the mist catcher 44)); the pH value falls within a predetermined range; and the SO_4 ion concentration becomes not more than a certain value. An explanation of a specific control method is omitted.

[0036] As above, in the present embodiment, the liquid area 37 of the cleaning portion 33 and the liquid area 41 of the cooling portion 34 are directly connected to each other in the outer frame case 51, and the cleaning liquid in the water pooling portion 47 integrally constituted by the liquid areas 37 and 41 is pumped up to be injected from the injection nozzle 39. Therefore, the cleaning liquid to be injected from the injection nozzle 39 does not have to be pumped up from a surge tank or the like. On this account, the EGR unit 30 does not require the surge tank or the like, and therefore, the EGR unit 30 can be reduced in size. With this, the EGR unit 30 according to the present embodiment may be mounted on the engine 10 depending on the engine 10.

[0037] The EGR unit 30 of the present embodiment does not include the surge tank, and the cleaning liquid is integrally pooled in the water pooling portion 47 located at a lower portion of the cleaning portion 33 and a lower portion of the cooling portion 34 in the outer frame case 51. Therefore, the amount of cleaning liquid circulating in the EGR unit 30 can be suppressed. On this account, the response reaction of the pH value of the cleaning liquid by the addition of the neutralizing agent or the like is quick, and therefore, the pH value of the cleaning liquid can be maintained within an appropriate range. Since the neutralizing agent does not exist in the condensed water generated in the cooling portion 34, sulfur slightly remaining after the cleaning dissolves in the condensed water. As a result, the pH value of the condensed water normally becomes lower than the pH value of the cleaning liquid which has reacted with the exhaust gas in the cleaning portion 33. Even if the pH value of the condensed water of the cooling portion 34 and the pH value of the cleaning liquid of the cleaning portion 33 are different from each other as above, these liquids are quickly mixed with each other. This is because the water pooling portion 47 is integrally constituted by the liquid areas 37 and 41 in the present embodiment. Thus, the pH value can be controlled collectively. As a result, the removal of the SOx from the exhaust gas which is to be recirculated to the engine 10 can be efficiently performed. Since the pH value of the cleaning liquid flowing through the circulation pipe 54 of the circulation device 35 does not become too low, excessive countermeasures for the corrosion of the circulation pipe 54 are unnecessary. Further, for example, when the used cleaning liquid is discharged from the wastewater treatment unit 60 to the sea, it is thought that the pH value of the cleaning liquid conveyed from the EGR unit 30 to the wastewater treatment unit 60 can easily satisfy standard (wastewater standard) of the pH value for the discharge to the sea. Therefore, it is unnec-

essary to perform a neutralization treatment in the wastewater treatment unit 60.

[0038] The cleaning liquid pooled in the cleaning portion 33 is utilized as the cleaning liquid injected from the injection nozzle 39 of the cleaning portion 33. Therefore, a large pressure difference is not generated between an inlet portion and outlet portion of the circulation pipe 54. Therefore, it is unnecessary to increase the size of the circulating pump 55 of the circulation device 35, and the power consumption can be suppressed.

Embodiment 2

[0039] Next, Embodiment 2 will be explained in reference to Fig. 3. An engine system 200 according to the present embodiment is basically the same as the engine system 100 according to Embodiment 1 except that a cleaning method by the cleaning portion 33 is a combination of a spray method and a water pool method. Hereinafter, the cleaning/cooling device 31 according to the present embodiment will be mainly explained.

[0040] Fig. 3 is a schematic diagram showing the cleaning/cooling device 31 according to the present embodiment. The cleaning portion 33 of the cleaning/cooling device 31 according to the present embodiment includes a liquid area introduction passage 58. The liquid area introduction passage 58 extends from the inlet port 38 formed at the cleaning portion 33 to the inside of the cleaning liquid in the liquid area 41. The entire exhaust gas having flowed into the cleaning portion 33 can be introduced to the liquid area 41. The injection nozzle 39 is provided in the vicinity of the inlet port 38 of the liquid area introduction passage 58. The injection nozzle 39 injects the cleaning liquid to the exhaust gas having flowed into the cleaning portion 33 (liquid area introduction passage 58). It should be noted that the cleaning liquid injected from the injection nozzle 39 is the cleaning liquid pumped up from the water pooling portion 47. The exhaust gas to which the cleaning liquid has been injected flows through the liquid area introduction passage 58 to be emitted to the inside of the cleaning liquid in the liquid area 37. With this, the exhaust gas is further cleaned by the cleaning liquid pooled in the liquid area 37.

[0041] As above, a certain amount of cleaning liquid is pooled in the liquid area 37 of the cleaning portion 33. Therefore, by also using the pooled cleaning liquid, the cleaning by the spray method and the cleaning by the water pool method can be simultaneously performed. Therefore, the engine system 200 according to the present embodiment can more efficiently clean the exhaust gas.

[0042] The foregoing has explained the embodiments of the present invention in reference to the drawings. However, specific configurations are not limited to those embodiments. Design changes and the like within the scope of the present invention are included in the present invention. For example, even if the cleaning method of the cleaning portion 33 is a method other than the spray method and the water pool method, such a method is included in the present invention.

[0043] In the above embodiments, the liquid area 37 of the cleaning portion 33 and the liquid area 41 of the cooling portion 34 are directly connected to each other through the gap between the outer frame case 51 and the dividing member 53. However, these areas 37 and 41 may be directly connected to each other by a different configuration. For example, the present invention includes a case where: the gap is not formed between the outer frame case 51 and the dividing member 53; a through hole is formed on the dividing member 53; and the liquid areas 37 and 41 are directly connected to each other through the through hole. Similarly, the present invention includes a case where: the gap is not formed between the outer frame case 51 and the dividing member 53; the liquid areas 37 and 41 are coupled to each other through a short pipe; and the liquid areas 37 and 41 are directly connected to each other through the pipe.

[0044] Further, the present invention may be configured such that: the dividing member 53 is provided so as not to allow the communication between the cleaning portion 33 and the cooling portion 34 in the outer frame case 51; and a pipe, a duct, or the like through which the gas areas 36 and 40 communicate with each other and a pipe, a duct, or the like through which the liquid areas 37 and 42 communicate with each other are provided outside the outer frame case 51. The present invention may be configured such that: the liquid area 37 of the cleaning portion 33 and the liquid area 41 of the cooling portion 34 are completely separated from each other by a lower end of the dividing plate 53; and a pipe connected to the injection nozzle 39 and a Y-shaped pipe connected to the liquid area 37 and the liquid area 41 are provided. According to this configuration, the liquid in the liquid area 37 and the liquid in the liquid area 41 can meet in the Y-shaped pipe, and then, these liquids can be supplied to the injection nozzle 39. In any case, the water pooling portion 47 is constituted by the liquid area 37 of the cleaning portion 33 and the liquid area 41 of the cooling portion 34.

Industrial Applicability

[0045] An EGR unit not including a surge tank can be configured by including the cleaning/cooling device of the present invention in the EGR unit. Therefore, the present invention is useful in the technical field of EGR units.

Reference Signs List

[0046]

10	engine
30	EGR unit
31	cleaning/cooling device
33	cleaning portion

34	cooling portion
36	gas area
37	liquid area
39	injection nozzle
40	gas area
41	liquid area
51	outer frame case
52	inner wall
53	dividing member
100, 200	engine system

Claims

1. A cleaning/cooling device being a device constituting a part of an EGR unit,
the cleaning/cooling device comprising:

a cleaning portion configured to clean an exhaust gas by using a cleaning liquid; and
a cooling portion provided adjacent to the cleaning portion and configured to cool the exhaust gas cleaned by the cleaning portion, wherein:

the cleaning portion includes a liquid area in which the cleaning liquid used for cleaning is pooled;
the cooling portion includes a liquid area which receives condensed water generated by cooling the exhaust gas; and
the liquid area of the cleaning portion and the liquid area of the cooling portion are directly connected to each other.

2. The cleaning/cooling device according to claim 1, wherein:

the cleaning portion includes a gas area through which the cleaned exhaust gas flows;
the cooling portion includes a gas area through which the exhaust gas to be cooled flows; and
the gas area of the cleaning portion and the gas area of the cooling portion are directly connected to each other.

3. The cleaning/cooling device according to claim 2, wherein the cleaning portion and the cooling portion are defined by an inner wall of an outer frame case and a dividing member which divides an internal space of the outer frame case.

4. The cleaning/cooling device according to claim 3, wherein:

the gas area of the cleaning portion and the gas area of the cooling portion are directly connected to each other in a vicinity of an upper end of the dividing member; and
the liquid area of the cleaning portion and the liquid area of the cooling portion are directly connected to each other in a vicinity of a lower end of the dividing member.

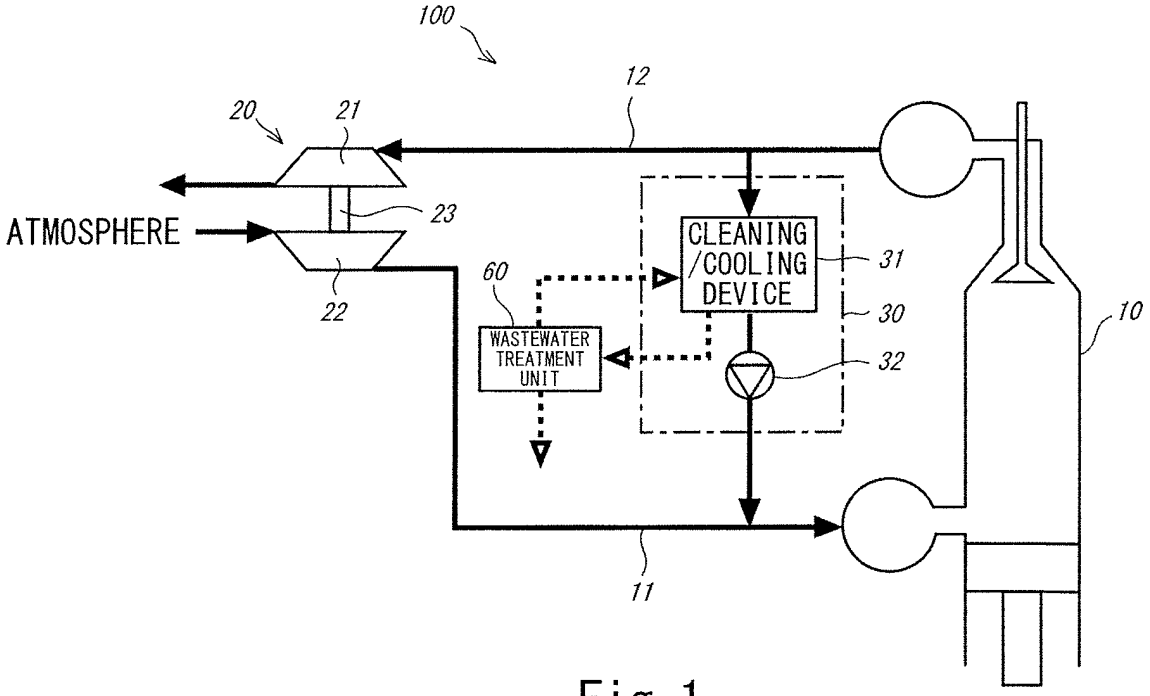
5. The cleaning/cooling device according to claim 4, wherein the dividing member has a plate shape.

6. The cleaning/cooling device according to any one of claims 1 to 5, wherein the cleaning portion pumps up the cleaning liquid in the liquid area and injects the cleaning liquid to the exhaust gas.

7. The cleaning/cooling device according to claim 6, wherein the cleaning portion emits the exhaust gas to an inside of the cleaning liquid in the liquid area.

8. An EGR unit comprising the cleaning/cooling device according to any one of claims 1 to 7, wherein
the exhaust gas cleaned and cooled by the cleaning/cooling device is recirculated to an engine.

9. An engine system comprising the EGR unit according to claim 8.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ATMOSPHERE
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WASTEWATER TREATMENT UNIT
CLEANING /COOLING DEVICE
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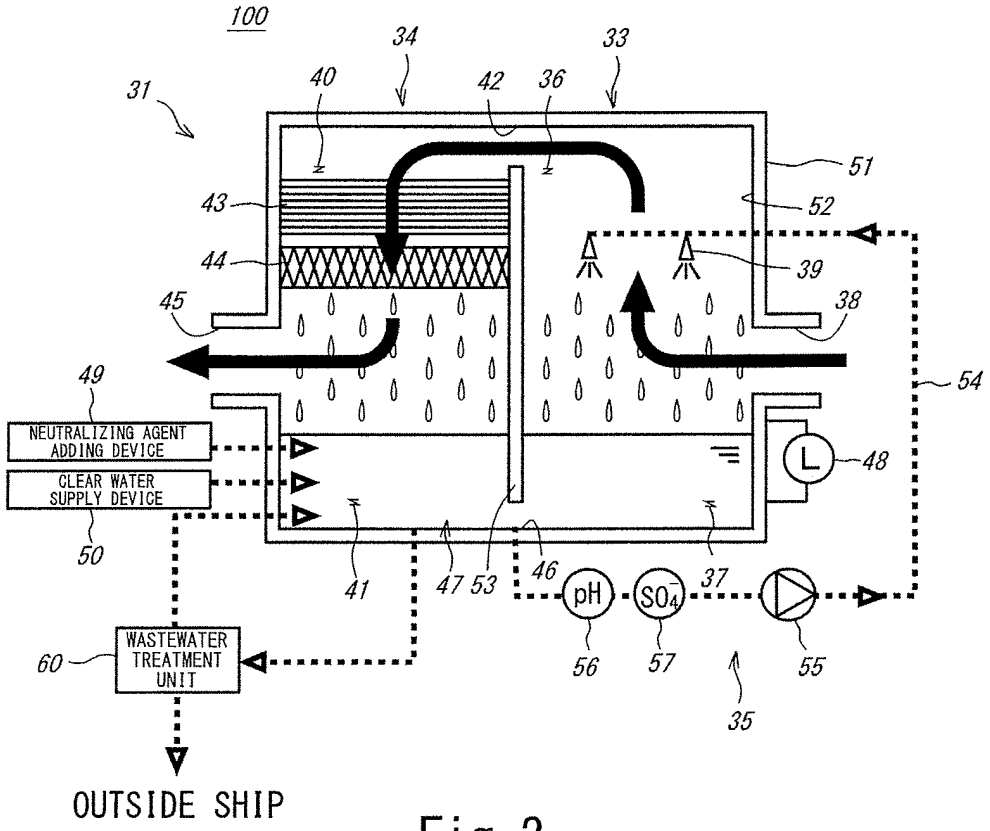
Fig. 1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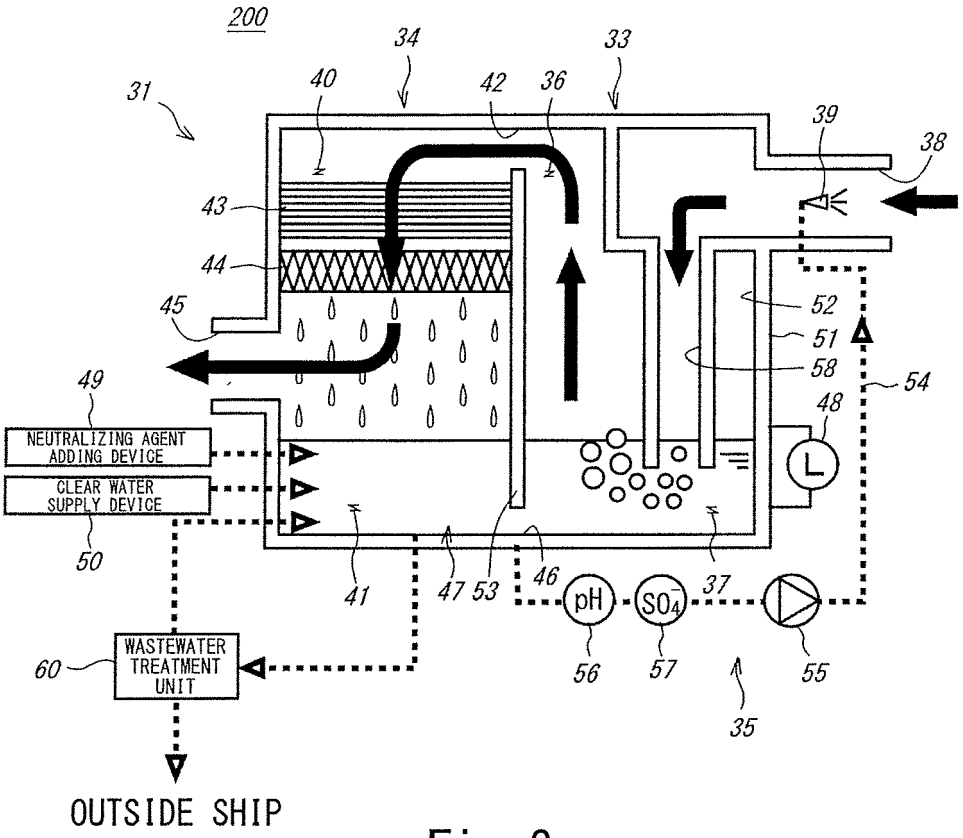
OUTSIDE SHIP

Fig. 2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OUTSIDE SHIP

Fig. 3

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2014/001551

A. CLASSIFICATION OF SUBJECT MATTER
F02M25/07(2006.01)i

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
F02M25/07

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
Jitsuyo Shinan Koho 1922-1996 Jitsuyo Shinan Toroku Koho 1996-2014
Kokai Jitsuyo Shinan Koho 1971-2014 Toroku Jitsuyo Shinan Koho 1994-2014

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X Y A	JP 2002-332919 A (Mitsubishi Heavy Industries, Ltd.), 22 November 2002 (22.11.2002), paragraphs [0032] to [0067]; fig. 1 to 4 & WO 2002/068809 A1	1-3,8-9 6-7 4-5
X Y A	JP 52-76525 A (Ikegai Iron Works, Ltd.), 28 June 1977 (28.06.1977), page 2, upper right column, line 3 to lower right column, line 16; fig. 1 (Family: none)	1-2,8-9 6-7 3-5
A	JP 2010-185413 A (Toyota Motor Corp.), 26 August 2010 (26.08.2010), paragraphs [0026] to [0046]; fig. 1 to 2 (Family: none)	1-9

☒ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

* Special categories of cited documents:
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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
30 April, 2014 (30.04.14)	13 May, 2014 (13.05.14)
Name and mailing address of the ISA/ Japanese Patent Office Facsimile No.	Authorized officer Telephone No.

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INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2014/001551

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	JP 2012-172647 A (Mitsui Engineering & Shipbuilding Co., Ltd.), 10 September 2012 (10.09.2012), entire text; all drawings (Family: none)	1-9

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REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- JP 2011157959 A **[0005]**