Problem] To suppress the production of by-products even when SO3 content in exhaust gas is high, or when urea solution is sprayed in a region in which the temperature of the exhaust gas is low.  

Solution] A urea solution spraying structure supplies ammonia to an SCR catalyst 6a of a denitrogenation reactor 6 of an exhaust-gas purifying device 7. The denitrogenation reactor 6 is arranged between an exhaust manifold 3 that collects exhaust gas discharged from exhaust connection pipes 2 connected to exhaust ports 1a of an engine 1 and an exhaust pathway 5 upstream of a turbine 4a of a turbo charger 4. The urea solution spraying structure includes an evaporation pipe 10 arranged in the exhaust manifold 3 and connected to a branch pipe 9 branched from an air supply pathway 8 downstream of a compressor 4b of the turbo charger 4, and a nozzle 11 that sprays urea solution in air that passes through the evaporation pipe 10.  

[Effect] Corrosion and obstruction of the exhaust pathway can be prevented, and performance of the SCR catalyst can be properly maintained.
UREA SOLUTION SPRAYING STRUCTURE

TECHNICAL FIELD

[0001] The present invention relates to a urea solution spraying structure for use in an exhaust-gas purifying device that purifies nitrogen oxides (hereinafter, "NOx"), contained in exhaust gas exhausted from an internal-combustion engine, by causing the NOx to react with a reducing agent in presence of a selective reduction catalyst (hereinafter, "SCR catalyst").

BACKGROUND ART

[0002] A technology for purifying NOx contained in exhaust gas is known in the art. For example, a denitrogenation reactor with an interposed SCR catalyst is installed downstream of an exhaust pipe of an engine, and ammonia gas is added as a reducing agent into an exhaust pathway upstream of the denitrogenation reactor to purify NOx contained in the exhaust gas in the denitrogenation reactor (See Patent Reference 1).

[0003] However, ammonia gas and ammonia water are highly toxic and therefore dangerous, and also are disadvantageous for various reasons such as they have strong and irritating odor and the like. Due to this, there are strict restrictions on loading of such material on ships and the like.Conventionally, when using exhaust-gas purifying devices that employ the SCR catalyst, a structure is often adopted in which urea, which is chemically stable, is used as a reducing agent precursor and stored in a tank in the form of urea solution. The urea solution is sprayed from a nozzle into the exhaust pathway upstream of the denitrogenation reactor (for example, see Patent Reference 2).

[0004] In the above structure, when the temperature in the exhaust pathway is sufficiently high, the urea solution sprayed from the nozzle into the exhaust pathway is hydrolyzed as represented by below Equation (1), before reaching the SCR catalyst, thereby producing ammonia gas (NH₃).
(NH₂)₂CO + H₂O → 2NH₃ + CO₂  ... (1)

0005 The ammonia gas produced by the hydrolysis is supplied to the SCR catalyst, and denitrogenation reactions, as those represented by below Equations (2) and (3), take place between ammonia and NOx contained in the exhaust gas on the SCR catalyst. As a result, NOx is decomposed into nitrogen and water and thus rendered harmless.

4NH₃ + 4NO + O₂ → 4N₂ + 6H₂O  ... (2)

2NH₃ + NO + NO₂ → 2N₂ + 3H₂O  ... (3)

0006 In this manner, in the exhaust-gas purifying device that employs the SCR catalyst, when urea solution must be used for safety reasons, it is required that the hydrolysis reaction represented by Equation (1) reliably takes place while the sprayed urea solution is flowing in the exhaust pathway. To achieve this, in a conventional NOx purifying device disclosed in Patent Reference 2, for example, a muffler is arranged between the nozzle that supplies the urea solution and a NOx catalyst converter. The muffler functions to promote production of ammonia.

0007 Moreover, in another conventional technique, in a four-cylinder diesel engine 102 for ships equipped with an exhaust manifold 101 as shown in FIG. 2, an evaporation pipe 107 that promotes hydrolysis of urea solution sprayed from a nozzle 105 is often arranged between the urea solution spraying nozzle 105 and an SCR catalyst 106. The urea solution spraying nozzle 105 and the SCR catalyst 106 are arranged in an exhaust pathway 104 upstream of a turbine 103a of a turbo charger 103.

0008 However, in diesel engines where C heavy oil having a high content of sulfur is used as fuel, the content of SO₃ in the exhaust gas is high. When the SO₃ in the exhaust gas and ammonia, produced as a result of hydrolysis of the urea solution, come into contact with each other in a region where the temperature has dropped due to spraying of the urea solution, salts such as ammonium sulfate ((NH₄)₂SO₄) and acid ammonium sulfate (NH₄HSO₄) are produced as by-products. When these by-products get piled up in the
exhaust pathway, they cause corrosion and obstruction of the exhaust pathway. When the by-products get piled up on the SCR catalyst as well, catalyst activity of the SCR catalyst decreases.

[0009] Particularly, when a configuration such as the muffler disclosed in Patent Reference 2 or the evaporation pipe 107 shown in FIG. 2 is used, the urea solution is sprayed into a region in which the temperature of the exhaust gas has dropped which region is downstream of the exhaust manifold in which the high-temperature exhaust gas having a temperature between 300°C and 450°C, for example, that has just been exhausted out of the exhaust ports of the engine is present. In this region, however, the mist of urea solution adheres to the wall surfaces and the wall surface temperature drops, thereby easily producing by-products. For example, even in engines that do not use the C heavy oil, when the urea solution adheres to the wall surfaces and the wall surface temperature drops, cyanuric acid is produced as a by-product as the hydrolysis of the urea solution does not progresses is a desired manner, leading to further piling up of material and the like in the exhaust pathway.

[0010] When the configuration such as the evaporation pipe 107 shown in FIG. 2 is used, the ammonia produced as a result of the hydrolysis of the urea solution is not evenly diffused in the exhaust gas, but instead supplied to the SCR catalyst 106 in an uneven manner. When this happens, the progress of the denitrogenation reaction represented by Equations (2) and (3) may become insufficient.

PRIOR ART REFERENCES PATENT REFERENCES


SUMMARY OF THE INVENTION

PROBLEM TO BE SOLVED BY THE INVENTION

[0012] In the conventional exhaust-gas purifying device, the urea solution is sprayed into an atmosphere of high SO$_3$ content in the exhaust gas because of the use of fuel with high sulfur content. As a result, the temperature of the exhaust gas drops, and the by-products such as ammonium sulfate and acid ammonium sulfate are easily produced. Furthermore, in conventional exhaust-gas purifying devices, when the sprayed urea solution adheres to the wall surfaces, by-products such as cyanuric acid and the like are easily produced. The present invention aims to address the problem of corrosion and obstruction of the exhaust pathway and a decrease in the performance of the SCR catalyst caused by the by-products.

MEANS FOR SOLVING THIS PROBLEM

[0013] A urea solution spraying structure according to the present invention is capable of supplying ammonia to an SCR catalyst of a denitrogenation reactor of an exhaust-gas purifying device. The denitrogenation reactor is arranged between an exhaust manifold collecting exhaust gas discharged from exhaust connection pipes connected to exhaust ports of an engine, and an exhaust pathway upstream of a turbine of a turbo charger. Major features of the urea solution spraying structure are that it includes an evaporation pipe arranged in the exhaust manifold and connected to a branch pipe branched from an air supply pathway downstream of a compressor of the turbo charger; and a nozzle that sprays urea solution in air introduced into the evaporation pipe via the branch pipe.

ADVANTAGEOUS EFFECTS OF THE INVENTION
[0014] In the urea solution spraying structure according to the present invention, the evaporation pipe connected to the branch pipe branched from the air supply pathway downstream of the compressor of the turbo charger is arranged in the exhaust manifold, and the spraying of urea solution and the hydrolysis into ammonia are completed inside the evaporation pipe. While high-temperature air compressed by the compressor passes in the evaporation pipe, the air is before introduction into the air-supply port of the engine and does not contain SO$_2$. Therefore, even when fuel with high sulfur content is used, the production of by-products such as ammonium sulfate and acid ammonium sulfate can be suppressed.

[0015] In addition, in the urea solution spraying structure according to the present invention, the wall surfaces of the evaporation pipe arranged in the exhaust manifold are sufficiently heated by the high-temperature exhaust gas that has just been discharged from the exhaust connection pipes. Therefore, sufficient temperature can be ensured in the region in which the urea solution is sprayed, so that the production of by-products such as cyanuric acid can also be prevented. Even if a by-product is produced in a low-load state of the engine and becomes attached to the wall surfaces of the evaporation pipe, the wall surfaces of the evaporation pipe again reach high temperatures when the engine is in a high-load state, so that the temporarily attached by-product are decomposed.

[0016] In this manner, according to the present invention, the production of by-products such as ammonium sulfate, acid ammonium sulfate, and cyanuric acid can be suppressed, corrosion and obstruction of the exhaust pathway can be prevented, and performance of the SCR catalyst can be properly maintained.

BRIEF DESCRIPTION OF THE DRAWINGS

[0017] FIG. 1 illustrates an example of a configuration of an exhaust-gas purifying device including a urea solution spraying structure according to the present invention.
FIG. 2 is a schematic view illustrating a configuration of a conventional diesel engine for ships.

EMBODIMENTS OF THE INVENTION

[0018] An object of the present invention is to suppress the production of the by-products, such as ammonium sulfate, acid ammonium sulfate, and cyanuric acid, in an exhaust-gas purifying device even when SO₂ content of the exhaust gas is high, or when urea solution is sprayed in a region where the temperature of the exhaust gas low. This object is achieved by employing the following structure.

A urea solution spraying structure capable of supplying ammonia to an SCR catalyst of a denitrogenation reactor of an exhaust-gas purifying device, the denitrogenation reactor being arranged between an exhaust manifold that collects exhaust gas discharged from exhaust connection pipes connected to exhaust ports of an engine and an exhaust pathway upstream of a turbine of a turbo charger includes

an evaporation pipe arranged in the exhaust manifold and connected to a branch pipe branched from an air supply pathway downstream of a compressor of the turbo charger, and

a nozzle that sprays urea solution in air introduced into the evaporation pipe via the branch pipe.

Embodyments

[0019] An exemplary embodiment of the present invention is explained below with reference to FIG. 1. In FIG. 1, reference numeral 1 denotes a four-cylinder diesel engine for ships to which a urea solution spraying structure according to the present invention is applied. The diesel engine is provided with an exhaust manifold 3 that collects high-temperature exhaust gas exhausted from exhaust connection pipes 2 respectively
connected to exhaust ports 1a of cylinder heads. The exhaust manifold 3 guides the
collected exhaust gas to an exhaust pathway 5 upstream of a turbine 4a of a turbo charger 4.
A major portion of the urea solution spraying structure according to the present invention is
implemented inside the exhaust manifold 3 and arranged continuously with the exhaust
manifold 3. The portion includes a denitrogenation reactor 6 and an exhaust-gas purifying
device 7 arranged between the exhaust pathway 5 upstream of the turbine 4a and the
exhaust manifold 3. Reference numeral 4b denotes a compressor for the turbo charger 4,
and reference numeral 8 denotes an air supply pathway through which air compressed by
the compressor 4b is supplied.

[0020] An evaporation pipe 10 is arranged in the exhaust manifold 3. The
evaporation pipe 10 is connected to a branch pipe 9 branched from a branching section 8a
of the air supply pathway 8 downstream of the compressor 4b. One end of the evaporation
pipe 10 is connected to the branch pipe 9 and the other end opens into the exhaust manifold
3 via ejection holes 10a.

[0021] Reference numeral 11 denotes a nozzle for spraying urea solution in air
introduced into the evaporation pipe 10 from the branch pipe 9. The air passing through the
evaporation pipe 10 is compressed by the compressor 4b and is in a high-temperature state.
Because this air has not yet been introduced into an air supply port of an engine 1, it does
not contain SO₃. In the urea solution spraying structure according to the teaching of the
present embodiment, the high-temperature air that does not contain SO₃ is introduced into
the evaporation pipe 10, and the urea solution is sprayed in the air within the evaporation
pipe 10 to promote hydrolysis of urea solution. Therefore, even when fuel having high
sulfur content is used for the engine, the production of by-products due to reaction of
ammonia and SO₃ is suppressed.

[0022] It is preferable that the nozzle 11 is arranged in a region (a region other than a
region A) in which the evaporation pipe 10 lies inside the exhaust manifold 3 than a region
in which the evaporation pipe 10 protrudes outside the exhaust manifold 3 (region A). This is because the wall surfaces of the evaporation pipe 10 can be maintained at high temperatures at all times by being directly exposed to the high-temperature exhaust gas that has just been exhausted from the exhaust openings of the exhaust connection pipes 2 so that the production of by-products due to low temperature can be suppressed.

[0023] More specifically, the evaporation pipe 10 can be arranged with the longitudinal direction thereof parallel to the direction in which the exhaust openings of the exhaust connection pipes 2 connected to the exhaust ports 1a of the cylinders of the engine 1 are arranged, and the nozzle 11 can be positioned such that a region B into which the urea solution sprayed from the nozzle 11 flows is opposite the exhaust openings of the exhaust connection pipes 2.

[0024] The denitrogenation reactor 6 includes an interposed SCR catalyst 6a that selectively removes NOx, by reduction, that is contained in the exhaust gas exhausted from the engine 1 and that is a cause of environmental contamination such generation of acid rain and photochemical smog. As the SCR catalyst 6a, a desired catalyst can be selected from metal oxide catalysts, for example, alumina, zirconia, vanadia / titania, or a zeolite catalyst. These catalysts can be combined. The SCR catalyst 6a can be carried on a catalyst carrier with a honeycomb structure, or can be housed in a casing. The urea solution spraying structure according to the present invention supplies ammonia in a completely hydrolyzed state to the SCR catalyst 6a.

[0025] In the present embodiment, a hydrolysis catalyst 12 that promotes hydrolysis of urea solution is arranged inside the evaporation pipe 10 downstream of the nozzle 11. The object of arranging the hydrolysis catalyst 12 is to increase the hydrolysis efficiency. Any desired catalyst can be used as the hydrolysis catalyst 12, such as a titanium oxide catalyst or an alkali metal catalyst, as long as it promotes ammonia production.
In the present embodiment, the ejection holes 10a are arranged downstream of the hydrolysis catalyst 12 of the evaporation pipe 10. The ammonia produced as a result of hydrolysis of urea solution is ejected toward the SCR catalyst 6a from these ejection holes 10a. Because the ammonia gas produced as a result of hydrolysis in the evaporation pipe 10 passes through these small-diameter ejection holes 10a and ejected under high pressure into the exhaust gas in the exhaust manifold 3, the ammonia gas is sufficiently diffused in the exhaust gas when supplied to the SCR catalyst 6a so that the denitrogenation reaction can progress sufficiently.

In the present embodiment, the evaporation pipe 10 provided with the nozzle 11 and the hydrolysis catalyst 12 is incorporated into the exhaust manifold 3. Therefore, compared with the conventional apparatus in which the evaporation pipe is arranged in the exhaust pathway 5 upstream of the turbine 4a, the required space can be decreased. Furthermore, according to the present embodiment, compared with the conventional apparatus in which the exhaust manifold and the exhaust pipe are arranged parallel, the length of the exhaust pathway to the turbo charger 4 can be decreased. Therefore, the loss of air pressure in the exhaust pathway can be advantageously decreased.

Reference numeral 13 denotes an air cooler arranged on the air supply pathway 8. The temperature of the air compressed by the compressor 4b increases and the air tends to expand; however, when the air expands, its density as well as volume decrease. To address this issue, the air is supplied to the engine 1 after lowering its temperature by cooling the air in the air cooler 13.

In the urea solution spraying structure according to the teaching of the present invention, when the air cooler 13 is arranged on the air supply pathway 8, it is preferable to locate the position at which the branch pipe 9 is branched from the air supply pathway 8 (branching section 8a) upstream than the air cooler 13. This is because it is more
effective to supply high-temperature air to the evaporation pipe 10 from the viewpoint of promoting hydrolysis of urea solution, according to the present invention.

Reference numeral 14 denotes a receiver tank disposed downstream of the air cooler 13. When the engine 1 starts using air, the air is rapidly supplied from the receiver tank 14. When the pressure in the receiver tank decreases due to outflow of the air, air is supplied from the compressor 4b to the receiver tank so that there is no shortage of air supply even when a large volume of air in excess of capacity is required instantaneously.

As explained above, in the urea solution spraying structure according to the present invention, the evaporation pipe connected to the branch pipe branched from the air supply pathway downstream of the compressor of the turbo charger is arranged in the exhaust manifold, and the urea solution is sprayed into the evaporation pipe so as to complete hydrolysis of ammonia. Therefore, even when fuel with high sulfur content is used in an engine, production of by-products such as ammonium sulfate and acid ammonium sulfate can be suppressed. Furthermore, the wall surfaces of the evaporation pipe arranged in the exhaust manifold are sufficiently heated by the high-temperature exhaust gas that has just been exhausted from the exhaust connection pipes so that sufficient temperature can be ensured in the region in which the urea solution is sprayed, and the production of by-products such as cyanuric acid can also be prevented.

The present invention is not limited to the above embodiment, and it goes without saying that the embodiment of the invention may be variously modified within the scope of the technical concepts of the claims.

For example, in the above embodiment, a constant amount of air is introduced into the evaporation pipe 10 from the air supply pathway 8 via the branch pipe 9. However, the denitrogenation process by the SCR catalyst 6a may not always be required. For example, the denitrogenation process may be omitted when the ship is travelling in an open sea. To achieve this, a switching valve can be arranged in the
branching section 8a so as to stop the entry of the air into the branch pipe 9 when the
denitrogenation process is not required so that all of the air can be sent to the air cooler 13.

INDUSTRIAL APPLICABILITY

5 [0034] The urea solution spraying structure according to the present invention can be
applied not only to diesel engines for ships but also to diesel engines for automobiles.

[0035] EXPLANATION OF REFERENCE NUMERALS

1 Engine
10 1a Exhaust port
  2 Exhaust connection pipe
  3 Exhaust manifold
  4 Turbo charger
  4a Turbine
15 4b Compressor
  5 Exhaust pathway
  6 Denitrogenation reactor
  6a SCR catalyst
  7 Exhaust-gas purifying device
20 8 Air supply pathway
  9 Branch pipe
  10 Evaporation pipe
  10a Ejection hole
  11 Nozzle
25 12 Hydrolysis catalyst
  13 Air cooler
**Patentkrav**

1. Spray-anordning for urea-opløsning, som kan tilføre ammoniak til en SCR-katalysator i en denitrogeneringsreaktor (6) i en renseindretning for udstødningsgas, hvilken denitrogeneringsreaktor (6) er anbragt mellem en udstødningsmanifold (3), som opsamlar udstødningsgas, der udledes fra udstødningsforbindelsesrør (2), som er forbundet med udstødningsåbninger (1a) af en motor (1), og en udstødningsvej (5) opstrøms af en turbine af en turbolader (4), omfattende:

- et fordampningsrør (10), som er anbragt i udstødningsmanifolden (3) og forbundet med et forgreningsrør (9), som forgrener sig fra en luftforsyningsvej (8) nedstrøms af en kompressor af turboladeren (4); og

- en dyse (11), som sprayer urea-opløsningen ind i højtemperaturluft, der føres ind i fordampningsrøret (10) via forgreningsrøret (9).

2. Spray-anordning for urea-opløsning ifølge krav 1, hvor dysen (11) er anbragt i et område af fordampningsrøret (10), hvor fordampningsrøret (10) ligger inden i udstødningsmanifolden (3).

3. Spray-anordning for urea-opløsning ifølge krav 1 eller 2, yderligere omfattende en hydrolysekatalysator (12), som er anbragt inden i fordampningsrøret (10) nedstrøms af dysen (11) for at fremme hydrolyse af en urea-opløsning.

4. Spray-anordning for urea-opløsning ifølge krav 3, hvor fordampningsrøret (10) har udstødningshuller (10a) nedstrøms i forhold til hydrolysekatalysatoren (12), som udsender ammoniak produceret ved hydrolysen af en urea-opløsning til SCR-katalysatoren.
5. Spray-anordning for urea-opløsning ifølge et hvilket som helst af kravene 1 til 4, yderligere omfattende en luftkøler (13), som er anbragt på luftforsyningsvejen (8), således at forgreningsrøret (9) afgrenes fra luftforsyningsvejen (8) opstrøms af luftkøleren (13).
SEARCH REPORT - PATENT

Application No. PA 2014 70377

1. □ Certain claims were found unsearchable (See Box No. I).

2. □ Unity of invention is lacking prior to search (See Box No. II).

A. CLASSIFICATION OF SUBJECT MATTER
   F 01 N 3/08 (2006.01); B 01 D 53/94 (2006.01); F 01 N 3/24 (2006.01)
   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)
   IPC/CPC: B01D, F01N

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
   DK, NO, SE, FI: IPC-classes as above.

Electronic database consulted during the search (name of database and, where practicable, search terms used)
   EPODOC, WPI, FULL TEXT: ENGLISH, GERMAN

C. DOCUMENTS CONSIDERED TO BE RELEVANT

<table>
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<th>Category</th>
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<td>DE 3821832 C1 (KRUPP MAK MASCHINENBAU GMBH) 2 November 1989 Column 1, line 58 - column 2, line 61 Figures 1 and 2</td>
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<td>A</td>
<td>JP 2011-220280 A (HITACHI ZOSEN CORPORATION) 4 November 2011 PAJ abstract Figure 1</td>
<td>1, 2, 5</td>
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Further documents are listed in the continuation of Box C.

* Special categories of cited documents:
  "A" Document defining the general state of the art which is not considered to be of particular relevance.
  "D" Document cited in the application.
  "E" Earlier application or patent but published on or after the filing date.
  "L" Document which may throw doubt on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified).
  "O" Document referring to an oral disclosure, use, exhibition or other means.

"P" Document published prior to the filing date but later than the priority date claimed.
"T" Document not in conflict with the application but cited to understand the principle or theory underlying the invention.
"X" Document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone.
"Y" Document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.
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Date of completion of the search report
12 April 2016

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<td>A</td>
<td>WO 94/04804 A1 (MAN B&amp;W DIESEL A/S) 3 March 1994 Page 6, line 9 - page 7, line 19 Figure 1</td>
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<td>DE 102004027593 A1 (MAN B&amp;W DIESEL AG) 29 December 2005 Paragraph [0018] Figure 2</td>
<td>1, 5</td>
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Box No. I  Observations where certain claims were found unsearchable

This search report has not been established in respect of certain claims for the following reasons:
1. ☐ Claims Nos.: because they relate to subject matter not required to be searched, namely:

2. ☐ Claims Nos.: because they relate to parts of the patent application that do not comply with the prescribed requirements to such an extent that no meaningful search can be carried out, specifically:

3. ☐ Claims Nos.: because of other matters.

Box No. II  Observations where unity of invention is lacking prior to the search

The Danish Patent and Trademark Office found multiple inventions in this patent application, as follows:
**SUPPLEMENTAL BOX**

Continuation of Box [.]