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(54) **Exhaust gas purifying apparatus**

Abgasreinigungsvorrichtung

Appareil de purification des gaz d'échappement

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Description

BACKGROUND OF THE INVENTION

[0001] The present invention relates to an exhaust gas purification apparatus and, more specifically, to an exhaust gas purification apparatus having a urea selective catalytic reduction (hereinafter referred to merely as SCR) system for reducing nitrogen oxides (NOx) in exhaust gas emitted from a diesel engine.

[0002] The urea SCR system has been developed for reducing NOx in exhaust gas emitted from a diesel engine. The urea SCR system employs an SCR catalyst for converting NOx into nitrogen (N₂) and water (H₂O) by chemical reaction between NOx and ammonia (NH₃) generated by hydrolysis of urea water.

[0003] The SCR catalyst is provided in the exhaust passage between the engine and the muffler. Furthermore, an oxidation catalyst and an injection valve for injecting urea water into the exhaust gas are provided upstream of the SCR catalyst. The oxidation catalyst oxidizes hydrocarbons (HC) and carbon monoxide (CO) in the exhaust gas into water (H₂O) and carbon dioxide (CO₂) and also promotes the oxidation of nitrogen oxide (NO) into nitrogen dioxide (NO₂). Another oxidation catalyst is provided downstream of the SCR catalyst for promoting the oxidation of ammonia unreacted with NOx so as to prevent emission of the unreacted ammonia into the atmosphere.

[0004] A diesel particulate filter (hereinafter referred to merely as DPF) is also provided in the exhaust passage between the engine and the muffler for reducing particulate matter (PM) such as carbon in the exhaust gas. The exhaust gas purification apparatus including the urea SCR system and the DPF has many components provided between the engine and the muffler and requires a large space for mounting of such components to a vehicle. Therefore, a downsized urea SCR system has been proposed for facilitating the installation of the system in the vehicle.

[0005] PCT International Publication WO 99/05402 A1 discloses an exhaust gas purification apparatus that includes a mixing device functioning as a gas-guiding device, an injection device for injecting urea water as a reducing agent and a catalytic device provided downstream of the injecting device and including a hydrolytic catalytic module and an SCR catalytic module. The hydrolytic catalytic module is provided upstream of the SCR catalytic module in the catalytic device. The same PCT International Publication discloses another exhaust gas purification device in which a second mixing device is provided between the injecting device and the catalytic device.

[0006] The exhaust gas purification apparatus of the above PCT International Publication has accomplished the improvement of the efficiency of chemical reaction by the catalytic module in the catalytic device by ensuring uniform distribution of the reducing agent in the exhaust gas with the aid of the exhaust gas flow caused by the

mixing device for reducing NOx in the exhaust gas effectively. In addition, the exhaust gas purification apparatus achieves reduction of the distance between the injection device and the catalytic device and of the structural space of the apparatus. However, for ensuring the time that is long enough for urea water to be hydrolyzed, the distance that the injected urea water moves before reaching catalytic device should be long so that the time for urea water or the reducing agent to stay upstream of the catalytic device is long enough for the hydrolysis of urea water. When the structural space of the exhaust gas purification apparatus is reduced, urea water is supplied to the SCR catalytic module without being hydrolyzed sufficiently into ammonia. The exhaust gas purification apparatus improves the efficiency of hydrolysis by providing the hydrolytic catalytic module in the catalytic device.

[0007] However, when the structural space of the exhaust gas purification apparatus is reduced, it is difficult for the apparatus to provide a distance between the hydrolytic catalytic module and the SCR catalytic module that is long enough to ensure the reaction time for urea water to be hydrolyzed. Therefore, if the structural space of the exhaust gas purification apparatus is attempted to be reduced, the quantity of unreacted urea water supplied to the SCR catalytic module without being hydrolyzed into ammonia increases, with the result that the efficiency of the reduction of NOx in comparison to urea water usage deteriorates.

[0008] Furthermore, it is referred to DE 10 2005 012 066 A1, DE 197 34 627 C1, WO 2009/060 599 A1, JP 2006-274 845 A, and DE 2006 051 788 A1. These Publications disclose an exhaust gas purification apparatus according to the preamble of claim 1.

SUMMARY OF THE INVENTION

[0009] An object of the present invention is to provide an exhaust gas purification apparatus for improving the efficiency of the reduction of NOx in comparison to urea water usage.

[0010] The object is achieved by an exhaust gas purification apparatus as defined in claim 1. The dependent claims are directed to further developments of the invention.

BRIEF DESCRIPTION OF THE DRAWINGS

[0011] The invention together with further objects and advantages thereof may be best understood by reference to the following description of the presently preferred embodiments together with the accompanying drawings in which:

FIG. 1 is a schematic view showing an exhaust gas purification apparatus according to a first embodiment of the present invention and its associated components;

FIG. 2 is a schematic cross sectional view of the

exhaust gas purification apparatus of FIG. 1; and FIG. 3 is a schematic cross sectional view of an exhaust gas purification apparatus according to a second embodiment of the present invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

[0012] The following will describe the embodiments of the exhaust gas purification apparatus according to the present invention with reference to FIGS. 1 through 3. Referring to FIGS. 1 and 2 showing the first embodiment, the exhaust gas purification apparatus which is designated generally by 101 and its associated components will be described. The exhaust gas purification apparatus 101 is employed in a vehicle equipped with a diesel engine.

[0013] Referring to FIG. 1, an engine assembly including an engine 1 and the exhaust gas purification apparatus 101 is designated generally by reference numeral 10. The engine 1 has a plurality of cylinders 1A each having an intake port 1B to which an intake manifold 4 is connected for distributing intake air to the respective cylinders 1A. The intake manifold 4 has an inlet 4A to which an engine intake pipe 3 is connected and the engine intake pipe 3 is further connected to a compressor housing 8A of a turbocharger 8. The compressor housing 8A is connected to an intake pipe 2 through which outside air is introduced.

[0014] On the other hand, an exhaust manifold 5 is connected to a plurality of exhaust ports 1C of the engine 1 for collecting exhaust gas emitted from the respective exhaust ports 1C. An outlet 5A of the exhaust manifold 5 is connected to a turbine housing 8B of the turbocharger 8, to which the exhaust gas purification apparatus 101 having a substantially cylindrical shape is connected and disposed adjacent to a lateral side of the engine 1. The exhaust gas purification apparatus 101 is connected to an exhaust pipe 6, the downstream end of which is further connected to a muffler 7. The intake pipe 2, the turbocharger 8, the engine intake pipe 3 and the intake manifold 4 cooperate to form an intake system of the vehicle, while the exhaust manifold 5, the turbocharger 8, the exhaust gas purification apparatus 101, the exhaust pipe 6 and the muffler 7 cooperates to form an exhaust system of the vehicle. The engine 1, the engine intake pipe 3, the intake manifold 4, the exhaust manifold 5 and the turbocharger 8 cooperate to form the aforementioned engine assembly 10.

[0015] Referring to FIG. 2, the exhaust gas purification apparatus 101 includes a casing 11 having a substantially cylindrical shape. The casing 11 has an upstream end face 11A to which the outlet 8B2 of the turbine housing 8B of the turbocharger 8 is connected and a downstream end face 11B to which the upstream end 6A of the exhaust pipe 6 is connected. The casing 11 communicates internally with the turbine housing 8B and the exhaust pipe 6.

[0016] The cylindrical casing 11 houses therein an oxidation catalyst layer 12 supporting an oxidation catalyst and a diesel particulate filter (DPF) 14 as a particulate matter collecting device disposed downstream of the oxidation catalyst layer 12 with respect to the flow of exhaust gas in the casing 11. The oxidation catalyst layer 12 and the DPF 14 are made in the form of a layer extending perpendicular to the axis of a cylindrical portion 11C of the casing 11 over the entire radial dimension of the interior of the cylindrical portion 11C. The oxidation catalyst layer 12 and the DPF 14 are disposed spaced apart each other thereby to form therebetween a space 16.

[0017] The oxidation catalyst layer 12 supports thereon the oxidation catalyst for oxidizing hydrocarbons (HC) and carbon monoxide (CO) into water (H₂O) and carbon dioxide (CO₂) and also promoting the oxidation of nitrogen monoxide (NO) into nitrogen dioxide (NO₂). The oxidation catalyst of the oxidation catalyst layer 12 uses material such as platinum (Pt), palladium (Pd), rhodium (Rh), silver (Ag), iron (Fe), copper (Cu), nickel (Ni), gold (Au) or a mixture of two or more of these materials.

[0018] The DPF 14 is made of a porous material such as ceramic for capturing particulate matter (PM) contained in the exhaust gas. The DPF 14 has an (urea) SCR catalyst 15 as a selective catalytic reduction catalyst supported thereon, e.g., by coating. The selective catalytic reduction catalyst serves to promote the chemical reaction selectively among specific chemical substances. The SCR catalyst 15 catalyzes the reaction between nitrogen oxide (NO_x) and ammonia (NH₃) thereby to reduce NO_x into nitrogen (N₂) and water (H₂O). Material of the SCR catalyst 15 includes an oxide of zirconium (Zr), titanium (Ti), silicon (Si), cerium (Ce), or tungsten (W), a complex of these oxides and a ZSM-5 type zeolite partially replaced by a metal such as iron (Fe) and copper (Cu).

[0019] The oxidation catalyst layer 12 supports on at least a part of the downstream end surface 12B thereof with regard to the flow of exhaust gas, i.e., on the surface thereof facing the DPF 14, a hydrophilic layer 13 having a hydrophilic function and forming the urea decomposition accelerator of the invention. The hydrophilic layer 13 is formed by coating the end surface 12B of the oxidation catalyst layer 12 with a catalytic material that has a hydrolytic catalytic function for accelerating the hydrolysis and a hydrophilic function. This catalytic material having the hydrolytic catalytic function and the hydrophilic function includes a metal oxide such as silica (SiO₂), alumina (Al₂O₃), ceria (CeO₂), titania (TiO₂), tungsten oxide (WO₃) and the like. Material forming the hydrophilic layer 13 is made of a single metal oxide or a combination of the above metal oxides. The performance for hydrolysis of the hydrophilic layer 13 can be improved by adding silver (Ag) or platinum (Pt) other than the above metal oxides to the material forming the hydrophilic layer 13.

[0020] An injection valve 18 that is an electromagnetic valve is provided in the cylindrical portion 11C of the casing 11 at a position between the oxidation catalyst layer

12 (or the hydrophilic layer 13) and the DPF 14 (or the SCR catalyst 15). Specifically, the position is closer to the oxidation catalyst layer 12 (or the hydrophilic layer 13) than the DPF 14 (or the SCR catalyst 15). The injection valve 18 forms a urea water supplying device of the invention. The injection valve 18 is connected to a urea water tank 19 provided in a vehicle (not shown) and operable to inject urea water into the space 16 of the casing 11. The injection valve 18 is provided at a position that is adjacent to and immediately downstream of the hydrophilic layer 13 so that urea water is injected by the injection valve 18 toward the downstream end surface 12B of the oxidation catalyst layer 12, i.e., the downstream surface 13B of the hydrophilic layer 13. The injection valve 18 is electrically connected to a dosing control unit (DCU) 30 that controls the opening and closing operation of the injection valve 18. The urea water tank 19 has an electric pump for supplying urea water to the injection valve 18. The electric pump is electrically connected to the DCU 30 and the pump operation is controlled by the DCU 30.

[0021] A cylindrically-shaped mixer 17 is provided on the upstream end surface 14A of the DPF 14 for distributing substances in the exhaust gas uniformly over the end surface 14A. The mixer 17 has a structure that is similar to that disclosed in Published Japanese Translation H06-509020 of PCT international publication or Japanese Patent Application Publication 2006-9608. The mixer disclosed in Published Japanese Translation H06-509020 is made in the form of a lattice that divides the gas passage into plural cells so as to cause the gas flowing through each cell to flow spirally and also to flow toward the adjacent cell. This helps the substances in the exhaust gas to spread uniformly in the whole passage. On the other hand, the mixer disclosed in Japanese Patent Application Publication 2006-9608 has plural plates each extending perpendicularly to the direction of gas flow, which provides serpentine gas passage serving to distribute the substances in the gas uniformly.

[0022] Another oxidation catalyst layer 20 that supports oxidation catalyst for oxidizing ammonia is provided in the exhaust pipe 6 downstream of the exhaust gas purification apparatus 101. Platinum (Pt), palladium (Pd), silver (Ag), iron (Fe), copper (Cu), nickel (Ni), gold (Au) or the like may be employed as the material of the oxidation catalyst of the oxidation catalyst layer 20.

[0023] An exhaust gas temperature sensor 52 is provided upstream of the oxidation catalyst layer 12 and also downstream of the upstream end face 11A of the casing 11 for detecting the temperature of exhaust gas. The exhaust gas temperature sensor 52 is electrically connected to the DCU 30 and sends detected temperature information to the DCU 30. A first NOx sensor 51 is provided in the casing 11 at a position upstream of the exhaust gas temperature sensor 52 for detecting the NOx concentration and a second NOx sensor 53 is provided downstream of the downstream end face 11B of the casing 11, more specifically, at a position downstream of the

oxidation catalyst layer 20 in the exhaust pipe 6, for detecting the NOx concentration. The first and the second NOx sensors 51, 53 are electrically connected to the DCU 30 and send information about the NOx concentration to the DCU 30. As described above, the exhaust gas purification apparatus 101 having the SCR catalyst 15 and the DPF 14 integrated together is mounted to the engine assembly 10 at a position adjacent to the engine 1 (refer to FIG. 1).

[0024] The following will describe the operation of the exhaust gas purification apparatus 101 according to the first embodiment and its associated components with reference to FIGS. 1 and 2. Referring to FIG. 1, while the engine 1 is running, outside air is flowed into the compressor housing 8A of the turbocharger 8 through the intake pipe 2. The air is pumped by a compressor wheel (not shown) in the compressor housing 8A and flowed to the engine intake pipe 3 under an increased pressure. The air is flowed into a cylinder 1A in the engine 1 through the engine intake pipe 3 and the intake manifold 4. Then, the air in the cylinder 1A is mixed with fuel (light oil) supplied into the cylinder 1A and the fuel is ignited spontaneously for combustion.

[0025] Exhaust gas produced by the combustion is discharged into the exhaust manifold 5 through a plurality of exhaust ports 1C to be collected by the exhaust manifold 5 and then flows into the turbine housing 8B of the turbocharger 8. The exhaust gas flowing through the turbine housing 8B increases rotation speed of the turbine wheel (not shown) in the turbine housing 8B and the compressor wheel connected to the turbine wheel and then is discharged into the exhaust gas purification apparatus 101. After flowing through the exhaust gas purification apparatus 101, the exhaust gas flows through the oxidation catalyst layer 20, the exhaust pipe 6 and the muffler 7 and then is discharged outside the vehicle (not shown).

[0026] Referring to FIG. 2, all the exhaust gas flowed into the exhaust gas purification apparatus 101 flows firstly through the oxidation catalyst layer 12. While the exhaust gas flows through the oxidation catalyst layer 12, hydrocarbons and carbon monoxide in the exhaust gas are oxidized into carbon dioxide and water, and part of NO is oxidized into NO₂ that can be reduced easily. After flowing through the oxidation catalyst layer 12, the exhaust gas flows through the hydrophilic layer 13 and the mixer 17 and then into the DPF 14 supporting the SCR catalyst 15. PM in the exhaust gas is captured by the DPF 14.

[0027] Meanwhile, the DCU 30 activates the electric pump in the urea water tank 19 and also opens the injection valve 18 for injection of urea water from the injection valve 18 toward the hydrophilic layer 13 located upstream of the space 16.

[0028] The injected urea water is adsorbed on the surface 13B of the hydrophilic layer 13. Specifically, the urea water injected onto the surface 13B of the hydrophilic layer 13 is dispersed in radial directions of the cylindrical portion 11C of the casing 11 due to the hydrophilic prop-

erty of the hydrophilic layer 13 and is adsorbed uniformly on the surface 13B.

[0029] The oxidation catalyst layer 12 has therein the heat due to the exhaust gas flowing therethrough and also the reaction heat due to the oxidation of NO and the like in the exhaust gas. The urea water adsorbed on the surface 13B of the hydrophilic layer 13 is hydrolyzed into ammonia and carbon dioxide (CO₂) by the heat that the oxidation catalyst layer 12 has, the heat of the exhaust gas flowing through the hydrophilic layer 13 and also the hydrolytic catalytic function of the hydrophilic layer 13. The urea water is then adsorbed uniformly on the surface 13B of the hydrophilic layer 13 and, therefore, the reaction time required for the hydrolysis can be ensured, with the result that the urea water is hydrolyzed into ammonia effectively. Furthermore, since the urea water is dispersed and adsorbed uniformly on the surface 13B of the hydrophilic layer 13, ammonia is generated uniformly on the surface 13B of the hydrophilic layer 13.

[0030] Since the urea water dispersed and adsorbed on the hydrolytic catalyst as described above is hydrolyzed, the hydrolysis takes place with a high efficiency. Furthermore, the urea water can make use of the heat of hot exhaust gas immediately after being emitted from the turbocharger 8 of the engine 1. Therefore, the urea water can easily ensure the heat and the temperature required for the hydrolysis. Moreover, urea water is injected and hydrolyzed into ammonia in the region that is downstream of the oxidation catalyst layer 12 and, therefore, no ammonia flows into the oxidation catalyst layer 12 and is oxidized by the oxidation catalyst of the oxidation catalyst layer 12.

[0031] Ammonia generated on the hydrolysis is dispersed uniformly in radial directions of the cylindrical portion 11C of the casing 11 and flows to the mixer 17 together with the exhaust gas. Ammonia is further dispersed while flowing through the mixer 17 and then flows into the DPF 14. Ammonia that is flowed into the DPF 14 together with the exhaust gas reduces NO_x contained in exhaust gas including NO and NO₂ into N₂ by the catalytic reaction of the SCR catalyst 15. After being dispersed uniformly on the hydrophilic layer 13, ammonia is dispersed again at the mixer 17 and then supplied uniformly to the entire DPF 14 and the SCR catalyst 15, thereby reducing NO_x effectively at the SCR catalyst 15.

[0032] Unreacted ammonia which has not been used in the reduction of NO_x is discharged outside the exhaust gas purification apparatus 101 together with exhaust gas.

[0033] Therefore, the exhaust gas containing residual unreacted ammonia and N₂ after flowing through the DPF 14 where PM is removed is discharged from the exhaust gas purification apparatus 101 into the exhaust pipe 6. The exhaust gas thus discharged into the exhaust pipe 6 flows through the oxidation catalyst layer 20 provided in the exhaust pipe 6 and then is discharged through the muffler 7 outside the vehicle (not shown). Since the residual ammonia in the exhaust gas is oxidized and decomposed while flowing through the oxidation cat-

alyst layer 20, no harmful ammonia is discharged outside.

[0034] The catalyst has a characteristic that it activates the catalytic action at a temperature more than a predetermined temperature. The DCU 30 is operated to open the injection valve 18 when the temperature detected by the exhaust gas temperature sensor 52 is the predetermined temperature at which the SCR catalyst 15 is activated or higher, and to close the injection valve 18 when the detected temperature is under the predetermined temperature. Thus, the DCU 30 determines whether or not NO_x reduction should be performed depending on the temperature detected by the exhaust gas temperature sensor 52.

[0035] Furthermore, the DCU 30 controls the injection quantity of urea water by adjusting the opening of the injection valve 18 based on the NO_x concentration detected by the first NO_x sensor 51. Similarly, the DCU 30 controls the injection quantity of urea water by adjusting the opening of the injection valve 18 based on the NO_x concentration detected by the second NO_x sensor 53, that is the NO_x concentration of exhaust gas after flowing through the SCR catalyst 15 and the oxidation catalyst layer 20. For example, when the NO_x concentration detected by the second NO_x sensor 53 exceeds a predetermined level, the DCU 30 increases the injection quantity of urea water by opening the injection valve 18 further. Thus, the DCU 30 adjusts the supply quantity of urea water to the SCR catalyst 15, i.e., the supply quantity of ammonia, thereby controlling the NO_x reduction performance of the exhaust gas purification apparatus 101.

[0036] Referring to FIG. 1, the exhaust gas purification apparatus 101 is disposed adjacent to the engine 1 and, therefore, hot exhaust gas immediately after being emitted from the engine 1 flows into the exhaust gas purification apparatus 101 through the turbocharger 8. Furthermore, the heat generated by the engine 1 is imparted to the exhaust gas purification apparatus 101 located adjacent to the engine 1 and transmitted inward through outer wall of the casing 11.

[0037] Referring to FIG. 2, the oxidative catalyst layer 12, the hydrophilic layer 13 and the DPF 14 supporting the SCR catalyst 15 all disposed inside the casing 11 are subject to the heat of the hot exhaust gas and the heat imparted from the engine 1 and, therefore, the temperature of the respective components tends to increase. The temperature increasing rate of the respective components, i.e., the oxidation catalyst of the oxidation catalyst layer 12, the hydrophilic catalyst of the hydrophilic layer 13 and the SCR catalyst 15 in the exhaust gas purification apparatus 101 during a cold start of the engine 1 is improved and the time required for activating each catalyst is shortened. Eventually, the performance of NO_x reduction is improved.

[0038] Thus, the exhaust gas purification apparatus 101 of the present invention includes the oxidation catalyst layer 12 provided in exhaust gas passage, the hydrophilic layer 13 that is provided at least on the downstream end surface 12B of the oxidation catalyst layer

12 and having at least one of the hydrophilic function and the hydrolytic catalytic function, the SCR catalyst 15 provided downstream of the hydrophilic layer 13 and the injection valve 18 for supplying urea water to the hydrophilic layer 13.

[0039] The urea water supplied to the hydrophilic layer 13 is dispersed and adsorbed on the hydrophilic layer 13 by the hydrophilic function and can make use of the heat generated by the oxidation of NO to NO₂ and the heat of the exhaust gas flowing through the oxidation catalyst layer 12. Therefore, urea water is hydrolyzed very efficiently and ammonia resulting from the hydrolysis of the urea water is dispersed uniformly over the hydrophilic layer 13. Thus, the hydrolysis of urea water into ammonia is accomplished with high efficiency, which helps to improve the reaction of the ammonia in the SCR catalyst 15. The hydrolysis reaction of urea water supplied to the hydrophilic layer 13 is accelerated by the heat of the oxidation catalyst layer 12 and the heat due to the hydrolytic catalytic function of the hydrophilic layer 13, thereby improving the efficiency of the hydrolysis. Thus, the reduction of NO_x in the exhaust gas purification apparatus 101 using the urea water can be improved by the hydrophilic function and the hydrolytic catalytic function of the hydrophilic layer 13. Since the efficiency of hydrolysis of urea water is improved by providing the hydrophilic layer 13, the distance between the hydrophilic layer 13 and the SCR catalyst 15 can be shortened, thereby making it possible for the exhaust gas purification apparatus 101 to be made small.

[0040] Since the injection valve 18 supplies urea water at a position downstream of the hydrophilic layer 13, neither urea water is supplied to the oxidation catalyst layer 12 nor ammonia produced by the hydrolysis of urea water flows through the oxidation catalyst layer 12. Therefore, the oxidation of ammonia into NO_x by the oxidation catalyst of the oxidation catalyst layer 12 can be prevented. Due to the structure where the DPF 14 supports the SCR catalyst 15, the SCR catalyst 15 and the DPF 14 are formed integrally, thereby making it possible for the entire apparatus to be formed small. Furthermore, since the oxidation catalyst layer 12, the hydrophilic layer 13, the SCR catalyst 15 formed integrally with the DPF 14 and the injection valve 18 are all housed in the single casing 11, the entire apparatus can be made still smaller.

[0041] The exhaust gas purification apparatus 101 is mounted to the engine assembly 10 and the hot exhaust gas emitted from the engine assembly 10 is introduced into the exhaust gas purification apparatus 101. The heat that the engine assembly 10 generates in operation is transmitted inside the casing 11 of the exhaust gas purification apparatus 101. Therefore, the time for the temperature of the hydrophilic layer 13 to be increased to the level required for the hydrolysis of urea water and also for the temperature of the SCR catalyst 15 to the level required for activating the SCR catalyst 15 during a cold start of the engine can be shortened, with the result that the NO_x reduction performance can be improved.

[0042] The exhaust gas purification apparatus 102 according to a second embodiment of FIG. 3 is made by modifying the DPF 14 supporting the SCR catalyst 15 of the exhaust gas purification apparatus 101 according to the first embodiment. The following description will use the same reference numerals for the common elements or components in the first and the second embodiments, and the description of such elements or components will be omitted.

[0043] Referring to FIG. 3, the oxidation catalyst layer 12 having on the downstream side thereof the hydrophilic layer 13, an SCR catalyst layer 25 supporting the SCR catalyst and the DPF 24 are provided in this order in the downstream direction in the casing 11 of the exhaust gas purification apparatus 102. The oxidation catalyst layer 12 and the SCR catalyst layer 25 are disposed across the space 16 and the SCR catalyst layer 25 and the DPF 24 are disposed adjacent to each other. The mixer 17 is provided on the upstream end surface 25A of the SCR catalyst layer 25.

[0044] The exhaust gas introduced into the casing 11 flows through the mixer 17 after flowing through the oxidation catalyst layer 12 and the hydrophilic layer 13. NO_x contained exhaust gas is reduced into N₂ in the SCR catalyst layer 25, PM contained in exhaust gas is captured in the DPF 24 and the resulting exhaust gas is discharged outside the exhaust gas purification apparatus 102.

[0045] The rest of the structure and the operation of the exhaust gas purification apparatus 102 according to the second embodiment is the same as those of the exhaust gas purification apparatus 101 according to the first embodiment. The description of such structure or operation will be omitted.

[0046] The exhaust gas purification apparatus 102 according to the second embodiment offers the same advantageous effects as the exhaust gas purification apparatus 101 according to the first embodiment.

[0047] When PM is burned in the DPF 24 in the exhaust gas purification apparatus 102 for preventing the accumulation of PM, the influence of the combustion heat on the SCR catalyst of the SCR catalyst layer 25 is reduced as compared with the exhaust gas purification apparatus 101 according to the first embodiment. The exhaust gas purification apparatus 102 reduces the deterioration of the catalytic function of the SCR catalyst layer 25 due to the heat caused by burning PM and improves the durability of the SCR catalyst layer 25.

[0048] The exhaust gas purification apparatuses 101 and 102 according to the first and the second embodiments are provided in the engine assembly 10 having the turbocharger 8, respectively, but the present invention is not limited to this structure. When the engine assembly 10 dispenses with the turbocharger 8, the exhaust gas purification apparatuses 101 and 102 may be directly connected to the outlet 5A of the exhaust manifold 5, respectively. The exhaust gas purification apparatuses 101 and 102 may be provided spaced apart from the engine assembly 10, respectively.

[0049] In the second embodiment, the oxidation catalyst layer 12, the SCR catalyst layer 25, the DPF 24 and the injection valve 18 are all provided in the casing 11 of the exhaust gas purification apparatus 102, but the present invention is not limited to this structure. For example, only the DPF 24 may be provided outside the casing 11 separately from the other components.

[0050] In the first and second embodiments, the oxidation catalyst layer 20 is provided separately from the exhaust gas purification apparatuses 101, 102, but the present invention is not limited to this structure. The oxidation catalyst layer 20 may be provided inside the casing 11 downstream of the DPF 14, 24 of the exhaust gas purification apparatuses 101, 102, respectively.

[0051] The injection valve 18 is provided downstream of the oxidation catalyst layer 12 so as to supply urea water to the hydrophilic layer 13 in the exhaust gas purification apparatuses 101, 102 according to the first and the second embodiments, respectively, but the present invention is not limited to this structure. The injection valve may be so arranged that urea water is supplied toward the upstream side of the oxidation catalyst layer 12. The supplied urea water can be hydrolyzed while flowing through the oxidation catalyst layer 12 and, therefore, the efficiency of the hydrolysis of urea water can be improved. Since urea water is dispersed while flowing through the oxidation catalyst layer 12, urea water can be dispersed and adsorbed more uniformly on the hydrophilic layer 13. Accordingly, ammonia produced by the hydrolysis of urea water can be dispersed and be supplied to the SCR catalyst more uniformly. Thus, the efficiency of the reduction of NO_x by ammonia in the SCR catalyst is improved.

[0052] Although the hydrophilic layer 13 is supported on part of the downstream end surface 12B of the oxidation catalyst layer 12 in the first and the second embodiments, the hydrophilic layer 13 may be supported on the entire end surface 12B of the oxidation catalyst layer 12.

[0053] The single hydrophilic layer 13 having the hydrolytic catalytic function and the hydrophilic function is used as the urea decomposition accelerator in the first and the second embodiments, but the present invention is not limited to this structure. The single hydrophilic layer serving as the urea decomposition accelerator may be formed of two different layers, one layer of which is a hydrophilic layer made of a material having only the hydrophilic function and the other layer of which is a hydrolytic catalytic layer made of a material having only the hydrolytic catalytic function for accelerating the hydrolysis of urea water. In this case, the hydrophilic layer should preferably be provided downstream of the hydrolytic catalytic layer, that is on the side facing the DPF 14 and 24 of the first and the second embodiments, respectively.

[0054] The urea decomposition accelerator may be formed of only the hydrophilic layer made of the material having the hydrophilic function. Since urea water dispersed and adsorbed on the hydrophilic layer can make use of the heat of the oxidation catalyst layer 12, urea

water is hydrolyzed efficiently and the resulting ammonia is dispersed uniformly over the entire hydrophilic layer. On the other hand, the urea decomposition accelerator may be formed of only the hydrolytic catalytic layer made of the material having the hydrolytic catalytic function. In this case, urea water making use of the heat of the oxidation catalyst layer 12 is subject to the hydrolytic catalytic function by the hydrolytic catalytic layer and, therefore, the efficiency of the hydrolysis can be improved.

[0055] The casing 11 of the exhaust gas purification apparatuses 101, 102 according to the first and the second embodiments, respectively is cylindrically-shaped, but the casing 11 according to the present invention is not limited to this shape. The casing 11 may be formed with a cross-section including a prism such as quadratic prism, a sphere or an ellipsoid.

[0056] Furthermore, the mixer 17 may be dispensed with in the first and the second embodiments.

Claims

1. An exhaust gas purification apparatus (101, 102) comprising:

an oxidation catalyst (12) provided in a passage through which exhaust gas flows;

a urea decomposition accelerator (13), wherein the urea decomposition accelerator (13) is provided downstream of an end surface (12B) of the oxidation catalyst (12) and has at least one of a hydrophilic function and a hydrolytic catalytic function;

a selective catalytic reduction catalyst (15, 25) provided downstream of the urea decomposition accelerator (13); and

a urea water supplying device (18) for supplying urea water to the urea decomposition accelerator (13),

characterized in that the exhaust gas purification apparatus further comprises:

an exhaust gas temperature sensor (52) provided upstream of the oxidation catalyst (12) for detecting a temperature of the exhaust gas;

a first NO_x sensor (51) provided upstream of the oxidation catalyst (12) for detecting NO_x concentration;

a second NO_x sensor (53) provided downstream of the selective catalytic reduction catalyst (15, 25) for detecting NO_x concentration; and

a dosing control unit (30) electrically connected to the first and the second NO_x sensors (51, 53), the exhaust gas temperature sensor (52) and the urea water supplying device (18), wherein, when the temperature

- detected by the exhaust gas temperature sensor (52) is as high as a temperature at which the selective catalytic reduction catalyst (15, 25) is activated, the dosing control unit (30) activates the urea water supplying device (18) to supply urea water, and when the temperature detected by the exhaust gas temperature sensor (52) is under the temperature at which the selective catalytic reduction catalyst (15, 25) is activated, the dosing control unit (30) activates the urea water supplying device (18) to stop supplying urea water, wherein the dosing control unit (30) controls supply quantity of urea water based on NO_x concentrations detected by the first and the second NO_x sensors (51, 53).
2. The exhaust gas purification apparatus (101, 102) according to claim 1, **characterized in that** the urea water supplying device (18) supplies urea water toward a downstream surface (13B) of the urea decomposition accelerator (13).
 3. The exhaust gas purification apparatus (101, 102) according to any one of claims 1 and 2, **characterized in that** the urea water supplying device is an injection valve (18) provided at a position that is between the urea decomposition accelerator (18) and the selective catalytic reduction catalyst (15, 25) and closer to the urea decomposition accelerator (13) than the selective catalytic reduction catalyst (15, 25).
 4. The exhaust gas purification apparatus according to claim 1, **characterized in that** the urea water supplying device (18) supplies urea water upstream of the oxidation catalyst (12) and the urea water flows to the urea decomposition accelerator (13) after flowing through the oxidation catalyst (12).
 5. The exhaust gas purification apparatus (101, 102) according to any one of claims 1 and 4, **characterized in that** the exhaust gas purification apparatus further comprises:

a particulate matter collecting device (14, 24) for capturing particulate matter contained in the exhaust gas, wherein the particulate matter collecting device (14, 24) is formed integrally with the selective catalytic reduction catalyst (15, 25).
 6. The exhaust gas purification apparatus (102) according to claim 5, **characterized in that** the particulate matter collecting device (24) is provided downstream of the selective catalytic reduction catalyst (25).
 7. The exhaust gas purification apparatus (101, 102) according to any one of claims 5 and 6, **characterized in that** the exhaust gas purification apparatus further comprises:

a mixer (17) provided on an upstream end surface (14A, 25A) of the particulate matter collecting device (14) or the selective catalytic reduction catalyst (15, 25) for distributing substances in the exhaust gas over the end surface (14A, 25A) of the particulate matter collecting device (14) or the selective catalytic reduction catalyst (15, 25).
 8. The exhaust gas purification apparatus (101, 102) according to any one of claims 1 through 7, **characterized in that** the exhaust gas purification apparatus further comprises:

a casing (11) housing the oxidation catalyst (12), the urea decomposition accelerator (13), the selective catalytic reduction catalyst (15, 25) and the urea water supplying device (18).
 9. The exhaust gas purification apparatus (101, 102) according to any one of claims 1 through 8, **characterized in that** the exhaust gas purification apparatus is fixed to an engine assembly (10).
 10. The exhaust gas purification apparatus (101, 102) according to any one of claims 1 through 9, **characterized in that** the urea decomposition accelerator (13) is formed by coating the downstream end surface (12B) of the oxidation catalyst (12) with a material that has a hydrolytic catalytic function and a hydrophilic function.
 11. The exhaust gas purification apparatus (101, 102) according to claim 10, **characterized in that** the material includes at least one of silica (SiO₂), alumina (Al₂O₃), ceria (CeO₂), titania (TiO₂) and tungsten oxide (WO₃).

45 Patentansprüche

1. Abgasreinigungsvorrichtung (101, 102) mit:

einem Oxidationskatalysator (12), der in einem Durchlass vorgesehen ist, durch den Abgas strömt;

einem Harnstoff-Zersetzungsbeschleuniger (13), wobei der Harnstoff-Zersetzungsbeschleuniger (13) stromabwärts von einer Endfläche (12B) des Oxidationskatalysators (12) vorgesehen ist und eine hydrophile Funktion und/oder eine hydrolytisch-katalytische Funktion hat;

einem Katalysator zur selektiven katalytischen Reduktion (15, 25), der stromabwärts vom Harnstoff-Zersetzungsbeschleuniger (13) vorgesehen ist; und

einer Harnstoffwasser-Zuführeinrichtung (18) zum Zuführen von Harnstoffwasser zum Harnstoff-Zersetzungsbeschleuniger (13),

dadurch gekennzeichnet, dass die Abgasreinigungsvorrichtung außerdem Folgendes umfasst:

einen Abgastemperatursensor (52), der stromaufwärts vom Oxidationskatalysator (12) vorgesehen ist, um eine Temperatur des Abgases zu erfassen;

einen ersten NOx-Sensor (51), der stromaufwärts vom Oxidationskatalysator (12) vorgesehen ist, um eine NOx-Konzentration zu erfassen;

einen zweiten NOx-Sensor (53), der stromabwärts vom Katalysator zur selektiven katalytischen Reduktion (15, 25) vorgesehen ist, um eine NOx-Konzentration zu erfassen; und

eine Dosiersteuerungseinheit (30), die mit dem ersten und dem zweiten NOx-Sensor (51, 53), dem Abgastemperatursensor (52) und der Harnstoffwasser-Zuführeinrichtung (18) elektrisch verbunden ist, wobei die Dosiersteuerungseinheit (30), wenn die vom Abgastemperatursensor (52) erfasste Temperatur so hoch wie eine Temperatur ist, bei der der Katalysator zur selektiven katalytischen Reduktion (15, 25) aktiviert ist, die Harnstoffwasser-Zuführeinrichtung (18) so betätigt, dass sie Harnstoffwasser zuführt, und die Dosiersteuerungseinheit (30), wenn die von dem Abgastemperatursensor (52) erfasste Temperatur unter der Temperatur liegt, bei der der Katalysator zur selektiven katalytischen Reduktion (15, 25) aktiviert ist, die Harnstoffwasser-Zuführeinrichtung (18) so betätigt, dass sie aufhört, Harnstoffwasser zuzuführen, wobei die Dosiersteuerungseinheit (30) eine Zufuhrmenge an Harnstoffwasser beruhend auf NOx-Konzentrationen steuert, die von dem ersten und dem zweiten NOx-Sensor (51, 53) erfasst werden.

2. Abgasreinigungsvorrichtung (101, 102) nach Anspruch 1, **dadurch gekennzeichnet, dass** die Harnstoffwasser-Zuführeinrichtung (18) Harnstoffwasser zu einer stromabwärtigen Oberfläche (13B) des Harnstoff-Zersetzungsbeschleunigers (13) hin zuführt.

3. Abgasreinigungsvorrichtung (101, 102) nach einem

der Ansprüche 1 und 2, **dadurch gekennzeichnet, dass** die Harnstoffwasser-Zuführeinrichtung ein Einspritzventil (18) ist, das an einer Stelle vorgesehen ist, die sich zwischen dem Harnstoff-Zersetzungsbeschleuniger (18) und dem Katalysator zur selektiven katalytischen Reduktion (15, 25) und näher am Harnstoff-Zersetzungsbeschleuniger (13) als am Katalysator zur selektiven katalytischen Reduktion (15, 25) befindet.

4. Abgasreinigungsvorrichtung nach Anspruch 1, **dadurch gekennzeichnet, dass** die Harnstoffwasser-Zuführeinrichtung (18) Harnstoffwasser stromaufwärts vom Oxidationskatalysator (12) zuführt und das Harnstoffwasser zum Harnstoff-Zersetzungsbeschleuniger (13) strömt, nachdem es durch den Oxidationskatalysator (12) geströmt ist.

5. Abgasreinigungsvorrichtung (101, 102) nach einem der Ansprüche 1 und 4, **dadurch gekennzeichnet, dass** die Abgasreinigungsvorrichtung außerdem Folgendes umfasst:

eine Partikelsammeleinrichtung (14, 24) zum Einfangen von Partikeln, die im Abgas enthalten sind, wobei die Partikelsammeleinrichtung (14, 24) als eine Einheit mit dem Katalysator zur selektiven katalytischen Reduktion (15, 25) ausgebildet ist.

6. Abgasreinigungsvorrichtung (102) nach Anspruch 5, **dadurch gekennzeichnet, dass** die Partikelsammeleinrichtung (24) stromabwärts vom Katalysator zur selektiven katalytischen Reduktion (25) vorgesehen ist.

7. Abgasreinigungsvorrichtung (101, 102) nach einem der Ansprüche 5 und 6, **dadurch gekennzeichnet, dass** die Abgasreinigungsvorrichtung außerdem Folgendes umfasst:

einen Mischer (17), der auf einer stromaufwärtigen Endfläche (14A, 25A) der Partikelsammeleinrichtung (14) oder des Katalysators zur selektiven katalytischen Reduktion (15, 25) vorgesehen ist, um Substanzen im Abgas über die Endfläche (14A, 25A) der Partikelsammeleinrichtung (14) oder des Katalysators zur selektiven katalytischen Reduktion (15, 25) zu verteilen.

8. Abgasreinigungsvorrichtung (101, 102) nach einem der Ansprüche 1 bis 7, **dadurch gekennzeichnet, dass** die Abgasreinigungsvorrichtung außerdem Folgendes umfasst:

ein Gehäuse (11), das den Oxidationskatalysator (12), den Harnstoff-Zersetzungsbeschleuniger

ger (13), den Katalysator zur selektiven katalytischen Reduktion (15, 25) und die Harnstoffwasser-Zuführeinrichtung (18) beherbergt.

9. Abgasreinigungsvorrichtung (101, 102) nach einem der Ansprüche 1 bis 8, **dadurch gekennzeichnet, dass** die Abgasreinigungsvorrichtung an einer Motorbaugruppe (10) befestigt ist. 5
10. Abgasreinigungsvorrichtung (101, 102) nach einem der Ansprüche 1 bis 9, **dadurch gekennzeichnet, dass** der Harnstoff-Zersetzungsbeschleuniger (13) durch Beschichten der stromabwärtigen Endfläche (12B) des Oxidationskatalysators (12) mit einem Material, das eine hydrolytisch-katalytische Funktion und eine hydrophile Funktion hat, ausgebildet ist. 10 15
11. Abgasreinigungsvorrichtung (101, 102) nach Anspruch 10, **dadurch gekennzeichnet, dass** das Material Siliziumoxid (SiO₂), Aluminiumoxid (Al₂O₃ Ceroxid (CeO₂), Titanoxid (TiO₂) und/oder Wolframoxyd (WO₃) einschließt. 20

Revendications 25

1. Appareil (101, 102) de purification des gaz d'échappement comprenant : 25

un catalyseur d'oxydation (12) prévu dans un passage à travers lequel des gaz d'échappement s'écoulent ; 30
 un accélérateur (13) de décomposition d'urée, où l'accélérateur (13) de décomposition d'urée est prévu en aval d'une surface d'extrémité (12B) du catalyseur d'oxydation (12) et présente au moins l'une d'une fonction hydrophile et d'une fonction catalytique hydrolytique ; 35
 un catalyseur de réduction catalytique sélective (15, 25) prévu en aval de l'accélérateur (13) de décomposition d'urée ; et 40
 un dispositif (18) d'alimentation en eau d'urée permettant de fournir de l'eau d'urée à l'accélérateur (13) de décomposition d'urée, **caractérisé en ce que** l'appareil de purification des gaz d'échappement comprend en outre : 45

un capteur (52) de température des gaz d'échappement prévu en amont du catalyseur d'oxydation (12) destiné à détecter une température des gaz d'échappement ; 50
 un premier capteur de NO_x (51) prévu en amont du catalyseur d'oxydation (12) permettant de détecter la concentration en NO_x ; 55
 un deuxième capteur de NO_x (53) prévu en aval du catalyseur de réduction catalytique sélective (15, 25) permettant de détecter la

concentration en NO_x ; et
 une unité de commande de dosage (30) reliée électriquement aux premier et deuxième capteurs de NO_x (51, 53), au capteur (52) de température des gaz d'échappement et au dispositif (18) d'alimentation en eau d'urée, où, lorsque la température détectée par le capteur (52) de température des gaz d'échappement est aussi élevée qu'une température à laquelle le catalyseur de réduction catalytique sélective (15, 25) est activé, l'unité de commande de dosage (30) active le dispositif (18) d'alimentation en eau d'urée pour fournir l'eau d'urée, et lorsque la température détectée par le capteur (52) de température des gaz d'échappement est inférieure à la température à laquelle le catalyseur de réduction catalytique sélective (15, 25) est activé, l'unité de commande de dosage (30) active le dispositif (18) d'alimentation en eau d'urée pour arrêter l'alimentation en eau d'urée, où l'unité de commande de dosage (30) commande la quantité d'alimentation en eau d'urée sur la base des concentrations en NO_x détectées par les premier et deuxième capteurs de NO_x (51, 53).

2. Appareil (101, 102) de purification des gaz d'échappement selon la revendication 1, **caractérisé en ce que** le dispositif (18) d'alimentation en eau d'urée fournit l'eau d'urée vers une surface en aval (13B) de l'accélérateur (13) de décomposition d'urée.
3. Appareil 101, 102) de purification des gaz d'échappement selon l'une quelconque des revendications 1 et 2, **caractérisé en ce que** le dispositif d'alimentation en eau d'urée est une soupape d'injection (18) prévue au niveau d'une position qui se situe entre l'accélérateur (18) de décomposition d'urée et le catalyseur de réduction catalytique sélective (15, 25) et plus près de l'accélérateur (13) de décomposition d'urée que le catalyseur de réduction catalytique sélective (15, 25).
4. Appareil de purification des gaz d'échappement selon la revendication 1, **caractérisé en ce que** le dispositif (18) d'alimentation en eau d'urée fournit l'eau d'urée en amont du catalyseur d'oxydation (12) et l'eau s'écoule à l'accélérateur (13) de décomposition d'urée après passage à travers le catalyseur d'oxydation (12).
5. Appareil (101, 102) de purification des gaz d'échappement selon l'une quelconque des revendications 1 et 4, **caractérisé en ce que** l'appareil de purification des gaz d'échappement comprend en outre :

- un dispositif (14, 24) de collecte de matières particulaires permettant de capturer les matières particulaires contenues dans le gaz d'échappement, dans lequel le dispositif (14, 24) de collecte de matières particulaires est formé en un seul bloc avec le catalyseur de réduction catalytique sélective (15, 25). 5
6. Appareil de purification des gaz d'échappement (102) selon la revendication 5, **caractérisé en ce que** le dispositif (24) de collecte de matières particulaires est prévu en aval du catalyseur de réduction catalytique sélective (25). 10
7. Appareil de purification des gaz d'échappement (101, 102) selon l'une quelconque des revendications 5 et 6, **caractérisé en ce que** l'appareil de purification des gaz d'échappement comprend en outre : 15
- un mélangeur (17) prévu sur une surface d'extrémité amont (14A, 25A) du dispositif (14) de collecte de matières particulaires ou du catalyseur de réduction catalytique sélective (15, 25) pour distribuer des substances dans les gaz d'échappement au-dessus de la surface d'extrémité (14A, 25A) du dispositif (14) de collecte de matières particulaires ou du catalyseur de réduction catalytique sélective (15, 25). 20 25 30
8. Appareil de purification des gaz d'échappement (101, 102) selon l'une quelconque des revendications 1 à 7, **caractérisé en ce que** l'appareil de purification des gaz d'échappement comprend en outre : 35
- un boîtier (11) logeant le catalyseur d'oxydation (12), l'accélérateur (13) de décomposition d'urée, le catalyseur de réduction catalytique sélective (15, 25) et le dispositif (18) d'alimentation en eau d'urée. 40
9. Appareil de purification des gaz d'échappement (101, 102) selon l'une quelconque des revendications 1 à 8, **caractérisé en ce que** l'appareil de purification des gaz d'échappement est fixé à un ensemble moteur (10). 45
10. Appareil (101, 102) de purification des gaz d'échappement selon l'une quelconque des revendications 1 à 9, **caractérisé en ce que** l'accélérateur (13) de décomposition d'urée est formé par revêtement de la surface d'extrémité avale (12B) du catalyseur d'oxydation (12) avec un matériau qui a une fonction catalytique hydrolytique et une fonction hydrophile. 50 55
11. Appareil (101, 102) de purification des gaz d'échappement selon la revendication 10, **caractérisé en**

ce que le matériau comporte au moins l'un de la silice (SiO₂), de l'alumine (Al₂O₃), de l'oxyde de cérium (CeO₂), du dioxyde de titane (TiO₂) et de l'oxyde de tungstène (WO₃).

FIG. 1

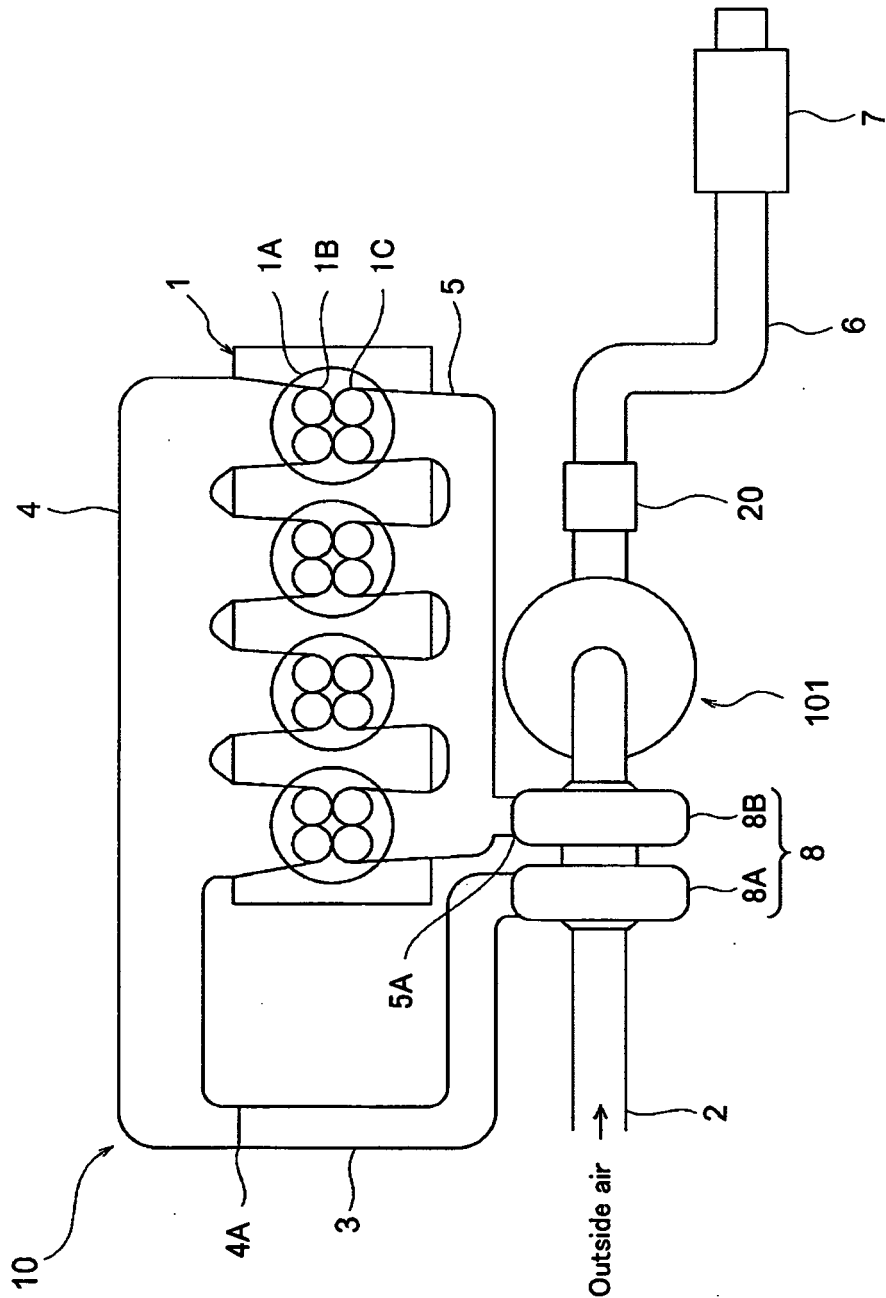


FIG. 2

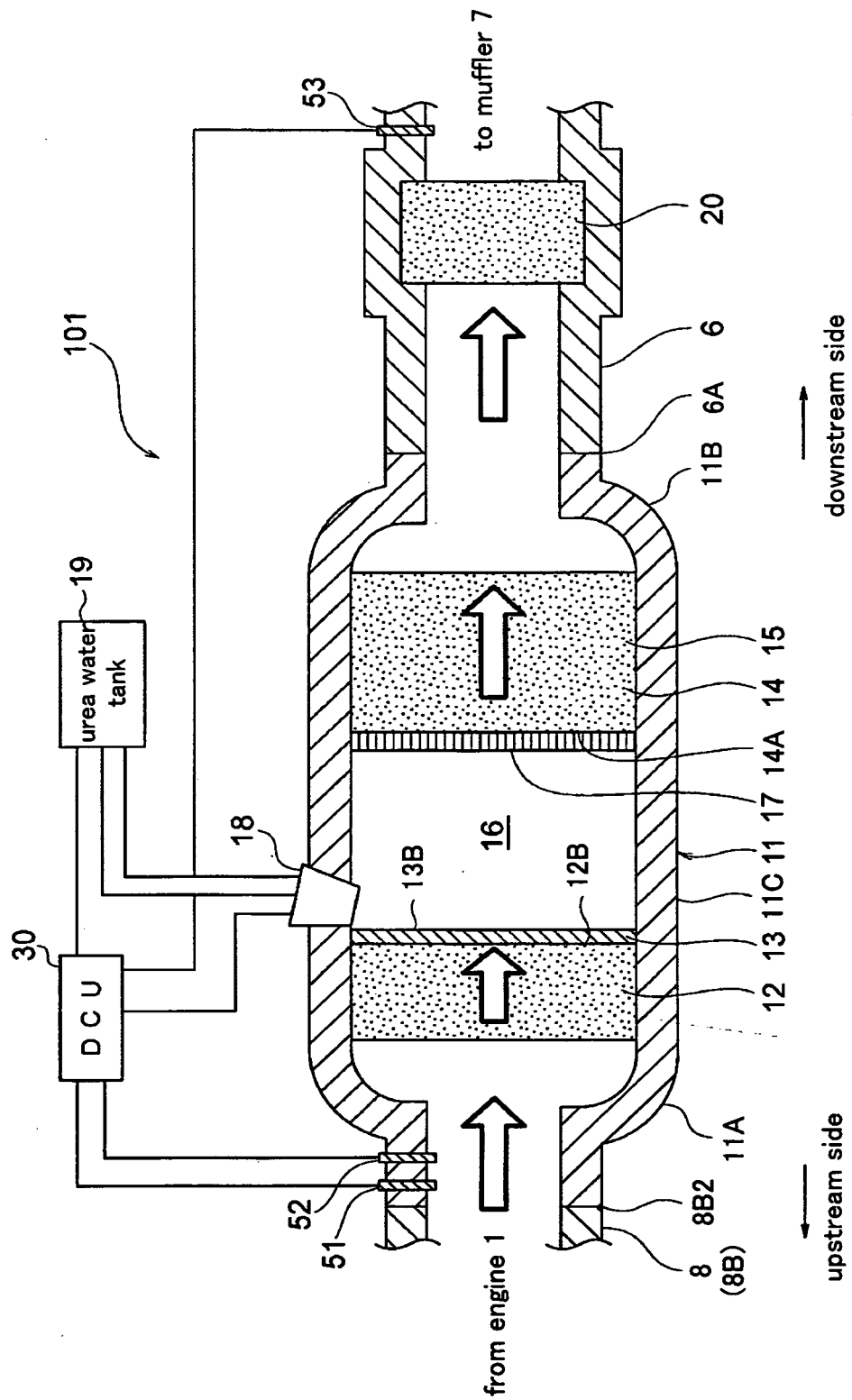
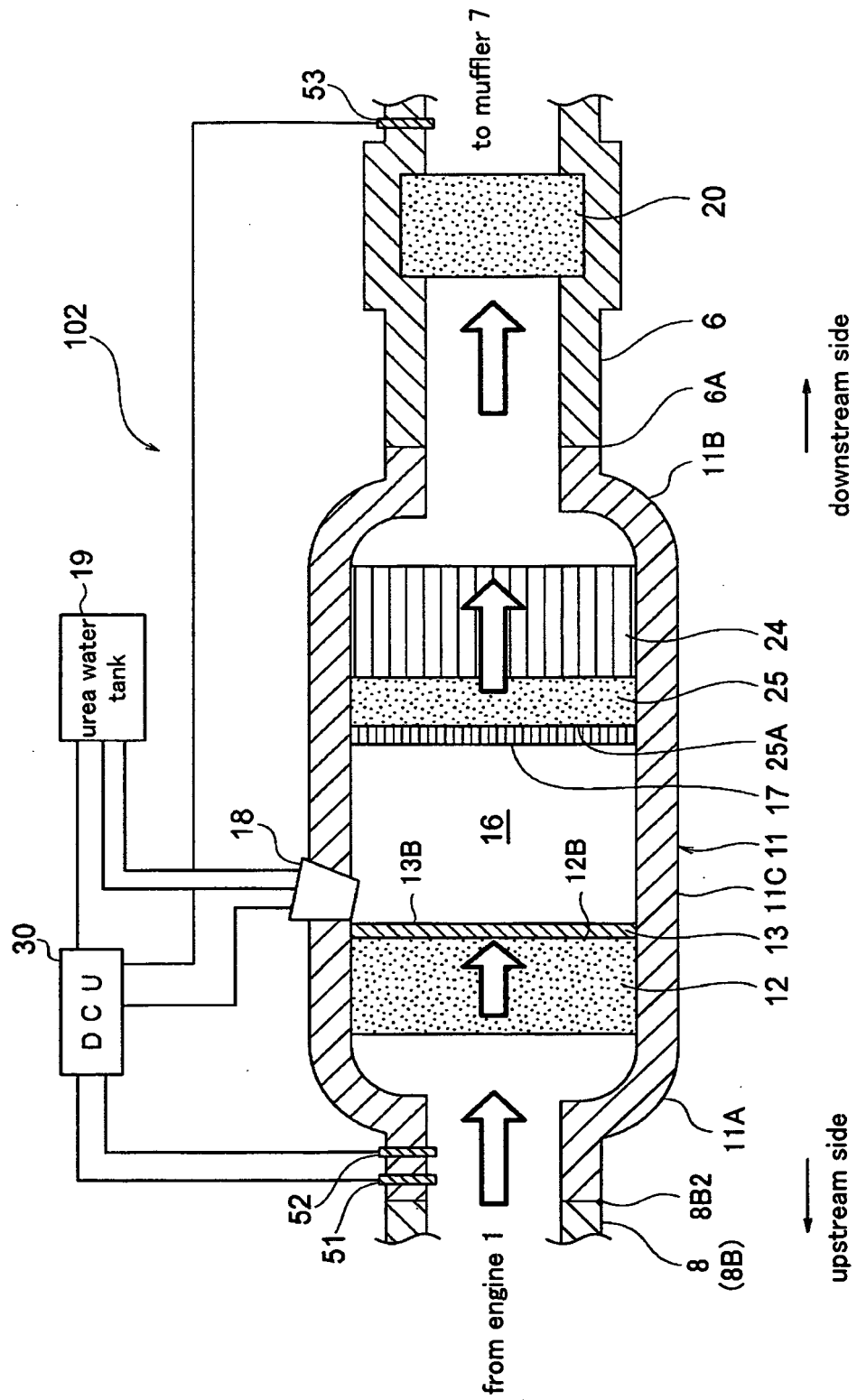


FIG. 3



REFERENCES CITED IN THE DESCRIPTION

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