EUROPEAN PATENT SPECIFICATION

EXHAUST EMISSION PURIFICATION APPARATUS OF COMPRESSION IGNITION INTERNAL COMBUSTION ENGINE

ABGAESEMISSIONS-REINIGUNGSVORRICHTUNG FÜR SELBSTZÜNDENDEN VERBRENNUNGSMOTOR

DISPOSITIF DE PURIFICATION D’EMISSIONS D’ÉCHAPPEMENT POUR MOTEUR A AUTO-ALLUMAGE

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Description

TECHNICAL FIELD

[0001] The present invention relates to an exhaust purification device of a compression ignition type internal combustion engine.

BACKGROUND ART

[0002] Known in the art is an internal combustion engine having arranged in an engine exhaust passage an NOx storing catalyst which stores NOx contained in exhaust gas when the air-fuel ratio of the inflowing exhaust gas is lean and releases the stored NOx when the oxygen concentration in the inflowing exhaust gas falls. In this internal combustion engine, the NOx produced when burning fuel under a lean air-fuel ratio is stored in the NOx storing catalyst.

[0003] However, when using such an NOx storing catalyst, it is necessary to make the NOx storing catalyst release the NOx before the NOx storing capability of the NOx storing catalyst becomes saturated. In this case, if making the air-fuel ratio of the exhaust gas flowing into the NOx storing catalyst rich, it is possible to make the NOx storing catalyst release NOx and to reduce the released NOx. Therefore, in conventional internal combustion engines, the NOx storing catalyst is made to release NOx by making the air-fuel ratio in the combustion chamber rich or by feeding fuel into the engine exhaust passage upstream of the NOx storing catalyst to make the air-fuel ratio of the exhaust gas flowing into the NOx storing catalyst rich.

[0004] However, to make an NOx storing catalyst release NOx well, sufficiently gasified rich air-fuel ratio exhaust gas has to be made to flow into the NOx storing catalyst. In this case, if making the air-fuel ratio in the combustion chamber rich, the sufficiently gasified rich air-fuel ratio exhaust gas flows into the NOx storing catalyst, so it is possible to make the NOx storing catalyst release the NOx well. However, if making the air-fuel mixture in the combustion chamber rich, there is the problem that a large amount of soot is produced. Further, if injecting additional fuel into the expansion stroke or exhaust stroke so as to make the air-fuel ratio of the exhaust gas exhausted from the combustion chamber rich, the injected fuel sticks to the inside walls of the cylinder bore, i.e., bore flushing occurs.

[0005] As opposed to this, when injecting fuel into the engine exhaust passage upstream of an NOx storing catalyst, the problems of soot being produced or bore flushing occurring as explained above no longer arise. However, when injecting fuel into the engine exhaust passage upstream of the NOx storing catalyst, there is the problem that the injected fuel is not sufficiently gasified and therefore the NOx storing catalyst cannot be made to release NOx well.

[0006] On the other hand, known in the art is an internal combustion engine arranging a hydrocarbon, that is, HC adsorbing catalyst for adsorbing HC contained in exhaust gas in the engine exhaust passage upstream of the NOx storing catalyst (see Japanese Unexamined Patent Publication (Kokai) No. 2003-97255). In this internal combustion engine, the HC produced when burning fuel under a lean air-fuel ratio is adsorbed by the HC adsorbing catalyst and the NOx produced at that time is stored in the NOx storing catalyst.

[0007] However, in this internal combustion engine, when the temperature of the HC adsorbing catalyst becomes near the activation temperature, that is, near 200°C, the oxidation reaction of the adsorbed HC becomes active and as a result the oxygen in the exhaust gas is rapidly consumed, so the oxygen concentration in the exhaust gas rapidly falls. Therefore, at this time, if additionally supplying a small amount of fuel, it is possible to make the air-fuel ratio of the exhaust gas rich. Therefore, in this internal combustion engine, it is detected whether a sufficient amount of oxygen has been consumed at the HC adsorbing catalyst, and the air-fuel ratio of the exhaust gas is made rich when a sufficient amount of oxygen is being consumed in the HC adsorbing catalyst so as to make the NOx storing catalyst release NOx.

[0008] However, in this internal combustion engine, the air-fuel ratio in the combustion chamber is made rich. Fuel is not injected into the engine exhaust passage. Therefore, the above problem arises. Further, in this internal combustion engine, the period when the temperature of the HC adsorbing catalyst becomes near the activation temperature, that is, the period when a sufficient amount of oxygen is consumed in the HC adsorbing catalyst, is limited, so the temperature of the HC adsorbing catalyst will not become the activation temperature in the period required as seen from the action of the NOx storing catalyst releasing the NOx and consequently there is the problem that the NOx storing catalyst cannot release NOx when the NOx storing catalyst has to release the NOx.

[0009] US 2003/0101713 A1 discloses systems and methods to improve the performance and emission control of internal combustion engines equipped with natural oxides storage reduction (“NSR”) emission control systems. The system comprises a NSR catalyst, a fuel processor located upstream of the NSR catalyst, and at least one fuel injection port.

DISCLOSURE OF THE INVENTION

[0010] An object of the present invention is to provide an exhaust purification device of a compression ignition type internal combustion engine designed to enable an NOx storing catalyst to release NOx well even when feeding fuel into the engine exhaust passage upstream of the NOx storing catalyst so as to make the NOx storing catalyst release NOx.

[0011] To achieve the above object, according to the present invention, provision is made of fuel adding means.
for adding particulate fuel into exhaust gas, an HC adsorbing and oxidation catalyst arranged in an engine exhaust passage downstream of the fuel adding means for NOx storing catalyst rich to make the NOx storing catalyst the HC adsorbing and oxidation catalyst for storing NOx arranged in the engine exhaust passage downstream of the HC adsorbing and oxidation catalyst for storing NOx contained in the exhaust gas when the air-fuel ratio of the inflowing exhaust gas is lean and releasing the stored NOx when the air-fuel ratio of the inflowing exhaust gas becomes the stoichiometric air-fuel ratio or rich, particulate fuel is added from the fuel adding means when making the air-fuel ratio of the exhaust gas flowing into the NOx storing catalyst rich to make the NOx storing catalyst release NOx.

The exhaust purification device is characterized in the oxidation catalyst being a HC adsorbing and oxidation catalyst for adsorbing and oxidizing hydrocarbons contained in the exhaust gas, the amount of addition of particulate fuel at this time is set to an amount whereby the air-fuel ratio of the exhaust gas flowing into the HC adsorbing and oxidation catalyst becomes a rich air-fuel ratio smaller than the rich air-fuel ratio when flowing into the NOx storing catalyst, and after added particulate fuel is adsorbed at the HC adsorbing and oxidation catalyst, and the majority of the adsorbed fuel is oxidized in the HC adsorbing and oxidation catalyst and the air-fuel ratio of the exhaust gas flowing into the NOx storing catalyst is made rich over a longer period than when the air-fuel ratio of the exhaust gas flowing into the HC adsorbing and oxidation catalyst is made rich. Preferred embodiments of the exhaust purification device are disclosed and claimed in the subclaims 1-16.

**BRIEF DESCRIPTION OF THE DRAWINGS**

FIG. 1 is an overview of a compression ignition type internal combustion engine.

FIG. 2 is an overview of another embodiment of a compression ignition type internal combustion engine.

FIG. 3 gives views of the structure of a particulate filter.

FIG. 4 is a sectional view of a surface part of a catalyst carrier of an NOx storing catalyst.

FIG. 5 is a side sectional view of an HC adsorbing and oxidation catalyst.

FIG. 6 is a sectional view of a surface part of a catalyst carrier of an HC adsorbing and oxidation catalyst.

FIG. 7 is a view of an amount of fuel adsorption.

FIG. 8 is a view of the change in the air-fuel ratio of exhaust gas.

FIG. 9 is a view of the relationship between a fuel addition time and an air-fuel ratio A/F of exhaust gas, a temperature rise ΔT, exhausted HC amount G, and a rich time.

FIG. 10 is a view of the change in the air-fuel ratio of exhaust gas.

FIG. 11 is a view of an amount of fuel addition.

FIG. 12 is a view of NOx release control.

FIG. 13 is a view of a map etc. of a stored NOx amount NOX.

FIG. 14 is a flow chart of exhaust purification processing.

FIG. 15 is a flow chart of fuel addition processing.

FIG. 16 is a flow chart of fuel addition processing.

FIG. 17 is a flow chart of fuel addition processing.

**BEST MODE FOR CARRYING OUT THE INVENTION**

FIG. 1 shows an overview of a compression ignition type internal combustion engine.

Referring to FIG. 1, 1 indicates an engine body, 2 a combustion chamber of each cylinder, 3 an electronically controlled fuel injector for injecting fuel into each combustion chamber 2, 4 an intake manifold, and 5 an exhaust manifold. The intake manifold 4 is connected through an intake duct 6 to an outlet of a compressor 7a of an exhaust turbocharger 7. The inlet of the compressor 7a is connected to an air cleaner 8. Inside the intake duct 6 is arranged a throttle valve 9 driven by a step motor. Further, around the intake duct 6 is arranged a cooling device 10 for cooling the intake air flowing through the inside of the intake duct 6. In the embodiment shown in FIG. 1, the engine cooling water is guided into the cooling device 10. The engine cooling water cools the intake air. On the other hand, the exhaust manifold 5 is connected to an inlet of an exhaust turbine 7b of the exhaust turbocharger 7, while the outlet of the exhaust turbine 7b is connected to an inlet of an HC adsorbing and oxidation catalyst 11. Further, the outlet of the HC adsorbing and oxidation catalyst 11 is connected through an exhaust pipe 13 to an NOx storing catalyst 12. The exhaust manifold 5 is provided with a fuel adding valve 14 for adding mist state, that is, particulate state fuel into the exhaust gas. In this embodiment of the present invention, this fuel is diesel oil.

The exhaust manifold 5 and the intake manifold 4 are interconnected through an exhaust gas recirculation (hereinafter referred to as an "EGR") passage 15. The EGR passage 15 is provided with an electronically controlled EGR control valve 16. Further, around the EGR passage 15 is arranged a cooling device 17 for cooling the EGR gas flowing through the inside of the EGR passage 15. In the embodiment shown in FIG. 1, the engine cooling water is guided into the cooling device 17. The engine cooling water cools the EGR gas. On the other hand, each fuel injector 3 is connected through a fuel feed tube 18 to a common rail 19.

This common rail 19 is supplied with fuel from an electronically controlled variable discharge fuel pump 20. The fuel supplied into the common rail 19 is supplied through each fuel feed tube 18 to the fuel injector 3.
An electronic control unit 30 is comprised of a digital computer provided with a ROM (read only memory) 32, a RAM (random access memory) 33, a CPU (microprocessor) 34, an input port 35, and an output port 36 all connected to each other by a bidirectional bus 31. The inlet of the HC adsorbing and oxidation catalyst 11 is provided with a temperature sensor 21 for detecting the temperature of the exhaust gas flowing into the HC adsorbing and oxidation catalyst 11, while the exhaust passage 13 is provided with a temperature sensor 22 for detecting the temperature of the exhaust gas flowing out from the HC adsorbing and oxidation catalyst 11. The output signals of the temperature sensors 21 and 22 are input through corresponding AD converters 37 to the input port 35. Further, the NOx storing catalyst 12 is provided with a differential pressure sensor 23 for detecting the differential pressure before and after the NOx storing catalyst 12. The output signal of the differential pressure sensor 23 is input through the corresponding AD converter 37 to the input port 35.

An accelerator pedal 40 has a load sensor 41 generating an output voltage proportional to the amount of depression L of the accelerator pedal 40 connected to it. The output voltage of the load sensor 41 is input through a corresponding AD converter 37 to the input port 35. Further, the input port 35 has a crank angle sensor 42 generating an output pulse each time the crankshaft turns for example by 15 degrees connected to it. On the other hand, the output port 36 is connected through corresponding drive circuits 38 to the fuel injectors 3, throttle valve 9 step motor, fuel adding valve 14, EGR control valve 16, and fuel pump 20.

FIG. 2 shows another embodiment of a compression ignition type internal combustion engine. In this embodiment, the HC adsorbing and oxidation catalyst 11 is provided with a temperature sensor 25 for detecting the temperature of the HC adsorbing and oxidation catalyst 11, while the exhaust passage 24 connected to the outlet of the NOx storing catalyst 12 is provided inside it with an air-fuel ratio sensor 26 for detecting the air-fuel ratio of the exhaust gas.

First, explaining the NOx storing catalyst 12 shown in FIG. 1 and FIG. 2, the NOx storing catalyst 12 is carried on a three-dimensional mesh structure monolithic carrier or pellet carriers or is carried on a honeycomb structure particulate filter. In this way, the NOx storing catalyst 12 can be carried on various types of carriers, but below, the explanation will be made of the case of carrying the NOx storing catalyst 12 on a particulate filter.

FIGS. 3(A) and (B) show the structure of the particulate filter 12a carrying the NOx storing catalyst 12. Note that FIG. 3(A) is a front view of the particulate filter 12a, while FIG. 3(B) is a side sectional view of the particulate filter 12a. As shown in FIGS. 3(A) and (B), the particulate filter 12a forms a honeycomb structure and is provided with a plurality of exhaust flow passages 60 and 61 extending in parallel with each other. These exhaust flow passages are comprised by exhaust gas inflow passages 60 with downstream ends sealed by plugs 62 and exhaust gas outflow passages 61 with upstream ends sealed by plugs 63. Note that the hatched portions in FIG. 3(A) show plugs 63. Therefore, the exhaust gas inflow passages 60 and the exhaust gas outflow passages 61 are arranged alternately through thin wall partitions 64. In other words, the exhaust gas inflow passages 60 and the exhaust gas outflow passages 61 are arranged so that each exhaust gas inflow passage 60 is surrounded by four exhaust gas outflow passages 61, and each exhaust gas outflow passage 61 is surrounded by four exhaust gas inflow passages 60.

The particulate filter 12a is formed from a porous material such as for example cordierite. Therefore, the exhaust gas flowing into the exhaust gas inflow passages 60 flows out into the adjoining exhaust gas outflow passages 61 through the surrounding partitions 64 as shown by the arrows in FIG. 3(B).

When the NOx storing catalyst 12 is carried on the particulate filter 12a in this way, the peripheral walls of the exhaust gas inflow passages 60 and exhaust gas outflow passages 61, that is, the surfaces of the two sides of the partitions 64 and inside walls of the fine holes of the partitions 64, carry a catalyst carrier comprised of alumina. FIGS. 4(A) and (B) schematically show the cross-section of the surface part of this catalyst carrier 45. As shown in FIGS. 4(A) and (B), the catalyst carrier 45 carries a precious metal catalyst 46 diffused on its surface. Further, the catalyst carrier 45 is formed with a layer of an NOx absorbent 47 on its surface.

In this embodiment of the present invention, platinum Pt is used as the precious metal catalyst 46. As the ingredient forming the NOx absorbent 47, for example, at least one element selected from potassium K, sodium Na, cesium Cs, or another alkali metal, barium Ba, calcium Ca, or another alkaline earth, lanthanum La, yttrium Y, or another rare earth may be used.

If the ratio of the air and fuel (hydrocarbons) supplied to the engine intake passage, combustion chambers 2, and exhaust passage upstream of the NOx storing catalyst 12 is referred to as the "air-fuel ratio of the exhaust gas", the NOx absorbent 47 performs an NOx absorption and release action of storing the NOx when the air-fuel ratio of the exhaust gas is lean and releasing the stored NOx when the oxygen concentration in the exhaust gas falls.

That is, if explaining this taking as an example the case of using barium Ba as the ingredient forming the NOx absorbent 47, when the air-fuel ratio of the exhaust gas is lean, that is, when the oxygen concentration in the exhaust gas is high, the NO contained in the exhaust gas is lean, that is, when the oxygen concentration in the exhaust gas is high, NOx is produced on the surface...
of the platinum Pt 46. So long as the NO\textsubscript{x} absorbing capability of the NO\textsubscript{x} absorbent 47 is not saturated, the NO\textsubscript{2} is absorbed in the NO\textsubscript{x} absorbent 47 and nitric acid ions NO\textsubscript{3}\textsuperscript{-} are produced.

As opposed to this, by making the air-fuel ratio of the exhaust gas rich or the stoichiometric air-fuel ratio, since the oxide concentration in the exhaust gas falls, the reaction proceeds in the reverse direction (NO\textsubscript{3}\textsuperscript{-} \rightarrow NO\textsubscript{2} and therefore, as shown in FIG. 4(B), the nitric acid ions NO\textsubscript{3}\textsuperscript{-} in the NO\textsubscript{x} absorbent 47 are released from the NO\textsubscript{x} absorbent 47 in the form of NO\textsubscript{2}. Next, the released NO\textsubscript{x} is reduced by the unburned hydrocarbons or CO included in the exhaust gas.

In this way, when the air-fuel ratio of the exhaust gas is lean, that is, when burning fuel under a lean air-fuel ratio, the NO\textsubscript{x} in the exhaust gas is absorbed in the NO\textsubscript{x} absorbent 47. However, if continuing to burn fuel under a lean air-fuel ratio, during that time the NO\textsubscript{x} absorbing capability of the NO\textsubscript{x} absorbent 47 will end up becoming saturated and therefore NO\textsubscript{x} will end up no longer being able to be absorbed by the NO\textsubscript{x} absorbent 47. Therefore, in this embodiment according to the present invention, before the absorbing capability of the NO\textsubscript{x} absorbent 47 becomes saturated, a reducing agent is supplied from the reducing agent supply valve 14 so as to temporarily make the air-fuel ratio of the exhaust gas rich and thereby release the NO\textsubscript{x} from the NO\textsubscript{x} absorbent 47.

Now, as explained above, if adding fuel from the fuel adding valve 14 to make the air-fuel ratio of the exhaust gas rich, the NO\textsubscript{x} absorbent 47 releases NO\textsubscript{x} and the released NO\textsubscript{x} is reduced by the unburned HC and CO contained in the exhaust gas. In this case, if the added fuel is in the liquid state, theoretically even if the air-fuel ratio of the exhaust gas becomes rich, the NO\textsubscript{x} absorbent 47 will not release NO\textsubscript{x}. Further, when the fuel is in the liquid state, the NO\textsubscript{x} will not be reduced. That is, to make the NO\textsubscript{x} absorbent 47 release NO\textsubscript{x} and to reduce the released NO\textsubscript{x}, it is necessary to make the air-fuel ratio of the gaseous ingredients in the exhaust gas flowing into the NO\textsubscript{x} storing catalyst 12 rich.

In the present invention, the fuel added from the fuel adding valve 14 is in the particulate state. Part of the fuel becomes a gaseous, but the majority is in the liquid state. In the present invention, even if the majority of the fuel added is in the liquid state, the HC adsorbing and oxidation catalyst 11 is arranged upstream of the NO\textsubscript{x} storing catalyst 12 so that the fuel flowing into the NO\textsubscript{x} storing catalyst 12 becomes gaseous. Next, the HC adsorbing and oxidation catalyst 11 will be explained.

FIG. 5 is a side sectional view of the HC adsorbing and oxidation catalyst 11. As shown in FIG. 5, the HC adsorbing and oxidation catalyst 11 forms a honeycomb structure and provides a plurality of exhaust gas passages 65 extending straight. The HC adsorbing and oxidation catalyst 11 is formed from a material with a large relative surface area having a porous structure such as zeolite. The base of the HC adsorbing and oxidation catalyst 11 shown in FIG. 5 is made of a type of zeolite, that is, mordenite. FIGS. 6(A) to (D) schematically show cross-sections of the surface part of the HC adsorbing and oxidation catalyst 11.

When particulate fuel is added from the fuel adding valve 14, part of the fuel evaporates and becomes gaseous, but the majority is adsorbed on the surface of a base 50 in the form of particles. FIGS. 6(A) and (B) show the state of adsorption of the fuel particles 53. The ratio of adsorption of fuel when fuel is adsorbed in the liquid state becomes considerably high compared with the ratio of adsorption of gaseous fuel. Note that the amount of adsorption of the particulate fuel which the HC adsorbing and oxidation catalyst 11 is able to adsorb, as shown in FIG. 7(A), becomes greater the lower the temperature of the HC adsorbing and oxidation catalyst 11.

Further, if the spatial velocity of the flow of exhaust gas in the HC adsorbing and oxidation catalyst 11 becomes faster, that is, if the flow rate of the exhaust gas becomes faster, the amount of the fuel added from the fuel adding valve 14 which is gasified and the amount of the particulate fuel passing straight through the exhaust passages 65 in the HC adsorbing and oxidation catalyst 11 will increase. Therefore, the amount of adsorption of the particulate fuel which the HC adsorbing and oxidation catalyst 11 can adsorb, as shown in FIG. 7(B), decreases the faster the spatial velocity.

Next, as shown in FIGS. 6(C) and (D), the fuel particles 53 adsorbed on the surface of the base 50 gradually evaporate to form gaseous fuel. This gaseous fuel is mainly comprised of HC with a large number of carbon atoms. The HC with the large number of carbon atoms is cracked at the acid points on the surface of the zeolite or on the precious metal catalyst 52 and converted to HC with a small number of carbon atoms. The converted gaseous HC immediately reacts with the oxygen in the exhaust gas to be oxidized. The majority of the fuel particles 53 adsorbed on the surface of the base 50 reacts with the oxygen in the exhaust gas, so almost all of the oxygen contained in the exhaust gas is consumed. As a result, the oxygen concentration in the exhaust gas falls and the NO\textsubscript{x} storing catalyst 12 releases the NO\textsubscript{x}.

On the other hand, at this time, the exhaust gas contains residual gaseous HC, so the air-fuel ratio of the exhaust gas becomes rich. This gaseous HC flows into the NO\textsubscript{x} storing catalyst 12, where the gaseous HC reduces the NO\textsubscript{x} released from the NO\textsubscript{x} storing catalyst 12.

FIG. 8 shows the amount of addition of fuel from the fuel adding valve 14 and the air-fuel ratio A/F of the
flowing into the NO\textsubscript{x} storing catalyst 12 becomes rich, if the air-fuel ratio A/F of the exhaust gas flowing out from the HC adsorbing and oxidation catalyst 11 is maintained at substantially the stoichiometric air-fuel ratio. Therefore, to produce a rich air-fuel ratio of about 14.0 over about 2 seconds and that at that time, NO\textsubscript{x} will be released well from the NO\textsubscript{x} storing catalyst 12. At this time, the air-fuel ratio of the exhaust gas flowing into the NO\textsubscript{x} storing catalyst 12 is rich longer. For this purpose, it becomes necessary to increase the amount of fuel adsorbed and held at the HC adsorbing and oxidation catalyst 11 as much as possible.

[0043] Giving an example, it is learned that in a compression ignition internal combustion engine where the amount of intake air per second becomes 10 (g) at the time of engine low speed, low load operation, if injecting particulate fuel from the fuel adding valve 14 for about 400 msec, the air-fuel ratio of the exhaust gas flowing into the NO\textsubscript{x} storing catalyst 12 will have a rich air-fuel ratio of about 14.0. Therefore, since A/F = 10 (g/sec)/F = 30, the amount of fuel injected becomes F = 1.3 (g/sec). On the other hand, to produce a rich air-fuel ratio of 14, since A/F = 10 (g/sec)/F = 14, 57 (g/sec) of fuel becomes necessary. Therefore, to produce a rich air-fuel ratio of
11, the amount of additional fuel to be added from the fuel adding valve 14 becomes 5/7 (g/sec)-1/3 (g/sec) = 8/21 (g/sec). To produce a rich air-fuel ratio of 14 over 2 seconds, it is necessary to add 16/21 (g) of fuel from the fuel adding valve 14. If adding this fuel in 400 msec, the air-fuel ratio of the exhaust gas at this time becomes about 4.4.

[0045] In this way, at the time of engine low speed, low load operation in this internal combustion engine, if trying to produce a rich air-fuel ratio of 14 over 2 seconds, it is necessary to supply 16/21 (g) of fuel from the fuel adding valve 14. In this case, if trying to supply this amount of fuel in a short time, for example, in 100 msec, it is necessary to raise the injection pressure of the fuel adding valve 14. However, if raising the injection pressure of the fuel adding valve 14, the fuel is made finer at the time of injection, so the amount of fuel which becomes a gas is increased and therefore the amount of fuel adsorbed at the HC adsorbing and oxidation catalyst 11 is reduced. That is, if the amount of fuel adsorbed on the HC adsorbing and oxidation catalyst 11 decreases, the time during which the air-fuel ratio becomes rich becomes smaller. As opposed to this, when supplying 16/21 (g) of fuel, if reducing the amount of supply per unit time, for example, if making the time of addition of fuel from the fuel adding valve 14 1000 msec, the amount of evaporation of fuel from the HC adsorbing and oxidation catalyst 11 per unit time becomes smaller and the air-fuel ratio of the exhaust gas is difficult to be made rich. FIG. 9 shows this.

[0046] That is, FIG. 9 shows the air-fuel ratio A/F of the exhaust gas flowing into the HC adsorbing and oxidation catalyst 11, the temperature rise ΔT of the exhaust gas flowing out from the HC adsorbing and oxidation catalyst 11, the exhausted HC amount G exhausted from the NOx storing catalyst 12, and the rich time of the exhaust gas flowing into the NOx storing catalyst 12 when changing the fuel addition time τ (msec) from the fuel adding valve 14.

[0047] As explained above, if making the fuel addition time from the fuel adding valve 14 shorter, the amount of fuel adsorbed at the HC adsorbing and oxidation catalyst 11 is reduced. As a result, the amount of evaporation of fuel from the HC adsorbing and oxidation catalyst 11 becomes smaller, so the oxidation action of the HC becomes weaker, the temperature rise ΔT falls, and the rich time becomes shorter. Further, at this time, the amount of fuel carried off by the flow of exhaust gas in the fuel supplied from the fuel adding valve 14 increases, so the exhausted HC amount G increases.

[0048] On the other hand, if making the fuel addition time from the fuel adding valve 14 longer, as explained above, the amount of fuel adsorbed per unit time at the HC adsorbing and oxidation catalyst 11 is reduced. As a result, the amount of evaporation of fuel from the HC adsorbing and oxidation catalyst 11 becomes smaller, so the oxidation action of the HC becomes weaker, the temperature rise ΔT falls, and the rich time becomes shorter. On the other hand, even after the action of release of NOx from the NOx storing catalyst 12 ends, HC continues to evaporate from the HC adsorbing and oxidation catalyst 11, so the exhausted HC amount G increases.

[0049] The fuel added when adding fuel from the fuel adding valve 14 is exhausted into the atmosphere, so that fuel is completely wasted. Therefore, it is necessary to suppress the amount of exhaust of the added fuel into the atmosphere, that is, the exhausted HC amount G, to an allowable value Go or less. The exhausted HC amount G being the allowable value Go or less, if looked at differently, means that the HC is engaging in an oxidation reaction and oxygen is being sufficiently consumed. Therefore, the exhausted HC amount G being the allowable value Go or less corresponds to the temperature rise ΔT being at least a predetermined setting ΔTg.

[0050] That is, when adding fuel from the fuel adding valve 14, it is necessary to determine the time τ of addition of the additional fuel so that the exhausted HC amount G becomes the allowable value Go or less and temperature rise ΔT becomes the set value ΔTg or more. Therefore, in this embodiment of the present invention, the time τ of addition of the additional fuel is set to from about 100 (msec) to about 700 (msec). If expressing this by the air-fuel ratio A/F, the air-fuel ratio A/F when the time τ of addition is 100 (msec) becomes about 1, while the air-fuel ratio A/F when the time τ of addition is 700 (msec) becomes about 7, so this embodiment of the present invention, at the time of engine low speed, low load operation, the amount of addition of particulate fuel added from the fuel adding valve 14 to make the NOx storing catalyst 12 release NOx is set to an amount giving an air-fuel ratio of the exhaust gas flowing into the HC adsorbing and oxidation catalyst 11 of about 1 to about 7.

[0051] FIG. 10 shows the air-fuel ratio at the same locations as FIG. 8 at the time of an engine high speed, high load operation. At the time of an engine high speed, high load operation, the temperature of the HC adsorbing and oxidation catalyst 11 becomes higher and the spatial velocity of the exhaust gas flowing through the HC adsorbing and oxidation catalyst 11 becomes higher compared with the time of engine low speed, low load operation, so, as will be understood from FIGS. 7(A) and (B), the amount of fuel which the HC adsorbing and oxidation catalyst 11 can adsorb falls considerably. Therefore, as will be understood if comparing FIG. 10 and FIG. 8, the amount of fuel added from the fuel adding valve 14 is made smaller at the time of engine high speed, high load operation compared with the time of engine low speed, low load operation.

[0052] Note that as shown in FIG. 10, at the time of engine high speed, high load operation, the air-fuel ratio is about 20, so even if the fuel added is reduced, the air-fuel ratio of the exhaust gas can be made rich. However, the time during which the air-fuel ratio of the exhaust gas can be made rich becomes considerably shorter compared with the time of engine low speed, low load operation.
indicates the maximum amount of NO\textsubscript{x} which the NO\textsubscript{x} is made a high value, in the embodiment shown in operating state, therefore the amount of NO\textsubscript{x} stored in the per unit time changes in accordance with the engine op-
change in the NO\textsubscript{x} amount \(\Sigma\)NO\textsubscript{x} stored in the NO\textsubscript{x} stor-
ing catalyst 12 per unit time also changes in case, even when the NO\textsubscript{x} storing catalyst 12 stores a
leased from the NO\textsubscript{x} storing catalyst 12.

A/F of the exhaust gas flowing into the NO\textsubscript{x} stor-
ng catalyst 12 is increased. If the amount of fuel added is in-
ceeds, so as explained above, the amount of fuel added from the fuel adding valve 14 is reduced. If the amount of fuel added is reduced in this way, it is only possible to make the NO\textsubscript{x} storing catalyst 12 release a small amount of NO\textsubscript{x}. That is, in this case, it is necessary to release the stored NO\textsubscript{x} after a small amount of NO\textsubscript{x} is stored in the NO\textsubscript{x} storing catalyst 12, as shown in FIG. 12(B), the allowable value NX is made a considerably low value, in the embodiment shown in FIG. 12(B), a value of 1/3 or less of the allowable value NX at the time of engine low speed, low load operation shown in FIG. 12(A).

FIG. 12(A) shows the change in the NO\textsubscript{x} amount \(\Sigma\)NO\textsubscript{x} stored in the NO\textsubscript{x} storing catalyst 12 and the timing for making the air-fuel ratio A/F of the exhaust gas rich for release of NO\textsubscript{x} at the time of engine low speed, low load operation, while FIG. 12(B) shows the change in the NO\textsubscript{x} amount \(\Sigma\)NO\textsubscript{x} stored in the NO\textsubscript{x} storing catalyst 12 and the timing for making the air-fuel ratio A/F of the exhaust gas rich for release of NO\textsubscript{x} at the time of engine high speed, high load operation.

The amount of NO\textsubscript{x} exhausted from the engine per unit time changes in accordance with the engine operating state, therefore the amount of NO\textsubscript{x} stored in the NO\textsubscript{x} storing catalyst 12 per unit time also changes in accordance with the engine operating state. In this embodiment of the present invention, the amount of NO\textsubscript{x} stored in the NO\textsubscript{x} storing catalyst 12 per unit time is stored as a function of the required torque TQ and the engine speed N in the form of a map shown in FIG. 13(A) in advance in the ROM 32. By cumulatively adding this NO\textsubscript{x} amount NO\textsubscript{X}, the NO\textsubscript{x} amount \(\Sigma\)NO\textsubscript{x} stored in the NO\textsubscript{x} storing catalyst 12 is calculated.

On the other hand, in FIGS. 12(A) and (B), MAX indicates the maximum amount of NO\textsubscript{x} which the NO\textsubscript{x} storing catalyst 12 can store, while NX indicates the allowable value of the amount of NO\textsubscript{x} which can be made to be stored in the NO\textsubscript{x} storing catalyst 12. Therefore, as shown in FIGS. 12(A) and (B), when the NO\textsubscript{x} amount \(\Sigma\)NO\textsubscript{x} reaches the allowable value NX, the air-fuel ratio A/F of the exhaust gas flowing into the NO\textsubscript{x} storing catalyst 12 is made temporarily rich and thereby NO\textsubscript{x} is released from the NO\textsubscript{x} storing catalyst 12.

As explained above, at the time of engine low speed, low load operation, the amount of fuel which the HC adsorbing and oxidation catalyst 11 can adsorb increases, so the amount of fuel added from the fuel adding valve 14 is increased. If the amount of fuel added is increased in this way, the NO\textsubscript{x} storing catalyst 12 can be made to release a large amount of NO\textsubscript{x}. That is, in this case, even when the NO\textsubscript{x} storing catalyst 12 stores a large amount of NO\textsubscript{x}, all of the stored NO\textsubscript{x} can be released, so, as shown in FIG. 12(A), the allowable value NX is made a high value, in the embodiment shown in FIG. 12(A), a value just slightly lower than the maximum NO\textsubscript{x} stored amount.

As opposed to this, at the time of engine high speed, high load operation, the amount of fuel adsorbed by the HC adsorbing and oxidation catalyst 11 decreases, so as explained above, the amount of fuel added from the fuel adding valve 14 is reduced. If the amount of fuel added is reduced in this way, it is only possible to make the NO\textsubscript{x} storing catalyst 12 release a small amount of NO\textsubscript{x}. That is, in this case, it is necessary to release the stored NO\textsubscript{x} after a small amount of NO\textsubscript{x} is stored in the NO\textsubscript{x} storing catalyst 12, as shown in FIG. 12(B), the allowable value NX is made a considerably low value, in the embodiment shown in FIG. 12(B), a value of 1/3 or less of the allowable value NX at the time of engine low speed, low load operation shown in FIG. 12(A).

In this way, the higher the engine load or the higher the engine speed, the lower the allowable value NX, so to make the NO\textsubscript{x} storing catalyst 12 release NO\textsubscript{x}, the higher the engine load or the higher the engine speed N, the higher the frequency of addition of particulate fuel from the fuel adding valve 14. That is, as shown in FIGS. 12(A) and (B), at the time of engine high speed, high load operation, the frequency of addition of particulate fuel becomes considerably higher compared with the time of engine low speed, low load operation.

On the other hand, the particulate matter contained in the exhaust gas is trapped on the particulate filter 12a carrying the NO\textsubscript{x} storing catalyst 12 and successively oxidized. However, if the amount of the particulate matter trapped becomes greater than the amount of the particulate matter oxidized, the particulate matter will gradually deposit on the particulate filter 12a. In this case, if the deposition of particulate matter increases, a drop in the engine output will end up being invited. Therefore, when the deposition of particulate matter increases, it is necessary to remove the deposited particulate matter. In this case, if raising the temperature of the particulate filter 12a under an excess of air to about 600°C, the deposited particulate matter is oxidized and removed.

Therefore, in this embodiment of the present invention, when the amount of the particulate matter deposited on the particulate filter 12a exceeds the allowable amount, the temperature of the particulate filter 12a is raised under a lean air-fuel ratio of the exhaust gas and thereby the deposited particulate matter is removed by oxidation. Specifically speaking, in this embodiment of the present invention, when the differential pressure \(\Delta P\) before and after the particulate filter 12a detected by the differential pressure sensor 23 exceeds the allowable value PX, it is judged that the amount of deposited par-
ticulate matter has exceeded the allowable amount. At that time, the air-fuel ratio of the exhaust gas flowing into the particulate filter 12a is maintained lean, fuel is added from the fuel adding valve 14, and the heat of oxidation reaction of the fuel added raises the temperature of the particulate filter 12a in temperature raising control.

[0064] FIG. 14 shows the exhaust purification processing routine.

[0065] Referring to FIG. 14, first, at step 100, the amount NOX of NOx stored per unit time is calculated from the map shown in FIG. 13(A). Next, at step 101, this NOX is added to the NOx amount ΣNOX stored in the NOx storing catalyst 12. Next, at step 102, the allowable value NX is calculated from the map shown in FIG. 13 (C). Next, at step 103, it is judged if the stored NOx amount ΣNOX has exceeded the allowable value NX. When ΣNOX>NX, the routine proceeds to step 104, where processing is performed to add fuel from the fuel adding valve 14. A basic example of this fuel addition processing is shown in FIG. 15. Two examples of correction of the amount of addition are shown in FIG. 16 and FIG. 17. Next, at step 105, the differential pressure sensor 23 is used to detect the differential pressure ΔP before and after the particulate filter 12a. Next, at step 106, it is judged if the differential pressure ΔP has exceeded the allowable value PX. When ΔP>PX, the routine proceeds to step 107, where temperature raising control of the particulate filter 12a is performed.

[0066] FIG. 15 shows the basic fuel addition processing when NOx should be released from the NOx storing catalyst 12. In this basic fuel addition processing, first, at step 150, the amount of fuel AQ to be added is calculated from the map shown in FIG. 11(B), then at step 151, the fuel, that is, diesel oil, of the amount AQ calculated from the map is added from the fuel adding valve 14.

[0067] However, if the air-fuel ratio of the exhaust gas flowing into the NOx storing catalyst 12 does not become rich due to some sort of reason even if adding an amount AQ of fuel predetermined in accordance with the engine operating state, the NOx storing catalyst 12 will not release NOx. Therefore, in this case, it is preferable to correct the amount of fuel added from the fuel adding valve 14 so that the air-fuel ratio of the exhaust gas flowing into the NOx storing catalyst 12 becomes rich. Therefore, in another embodiment of the present invention, provision is made of judging means for judging if the air-fuel ratio of the exhaust gas flowing out from the HC adsorbing and oxidation catalyst 11 has become rich when particulate fuel is added into the exhaust gas for making the NOx storing catalyst 12 release NOx. When NOx should be released from the NOx storing catalyst 12, the amount of fuel required for making the air-fuel ratio of the exhaust gas flowing out from the HC adsorbing and oxidation catalyst 11 rich is added according to judgment by this judging means.

[0068] As already explained based on FIG. 9, when the air-fuel ratio of the exhaust gas flowing into the NOx storing catalyst 12 is rich, the temperature rise ΔT of the exhaust gas passing through the HC adsorbing and oxidation catalyst 11 becomes the reference value ΔT0 or more. Therefore, in the first example shown in FIG. 1, when the temperature difference between the temperature detected by the temperature sensor 21 and the temperature detected by the temperature sensor 22, that is, the temperature rise ΔT, has exceeded the reference value ΔT0, it is judged that the air-fuel ratio of the exhaust gas flowing out from the HC adsorbing and oxidation catalyst 11 has become rich.

[0069] On the other hand, as shown in FIGS. 8(B) and (C) or FIGS. 10(B) and (C), when the air-fuel ratio A/F of the exhaust gas flowing out from the HC adsorbing and oxidation catalyst 11 becomes just slightly rich, the air-fuel ratio A/F of the exhaust gas flowing out from the NOx storing catalyst 12 becomes substantially the stoichiometric air-fuel ratio. Therefore, in the second example shown in FIG. 2, the air-fuel ratio sensor 26 is provided so as to detect the air-fuel ratio of the exhaust gas flowing out from the NOx storing catalyst 12. When the air-fuel ratio of the exhaust gas detected by the air-fuel ratio sensor 26 is substantially the stoichiometric air-fuel ratio, it is judged that the air-fuel ratio of the exhaust gas flowing out from the NOx adsorbing and oxidation catalyst 11 is rich.

[0070] Note that in the embodiment shown in FIG. 1 and FIG. 2, when it is judged that the air-fuel ratio of the exhaust gas flowing out from the HC adsorbing and oxidation catalyst 11 is not rich, the amount of particulate fuel added from the fuel adding valve 14 is increased. The action of increase of the amount of fuel added is performed for example by increasing the pulse like fuel addition time.

[0071] On the other hand, when it is judged that the air-fuel ratio of the exhaust gas flowing out from the HC adsorbing and oxidation catalyst 11 is not rich, the action of addition of fuel from the fuel adding valve 14 is already completed. Therefore, at this time, when it is next judged that the NOx storing catalyst 12 should release NOx, the amount of particulate fuel added from the fuel adding valve 14 is increased.

[0072] FIG. 16 shows the fuel addition control in the case of using the temperature sensors 21 and 22 to detect the temperature rise ΔT of the exhaust gas passing through the HC adsorbing and oxidation catalyst 11 in FIG. 1.

[0073] Referring to FIG. 16, first, at step 200, the amount of fuel added AQ is calculated from the map shown in FIG. 11(B). Next, at step 201, the amount of fuel added AQ is multiplied with a correction coefficient K to calculate the final amount of fuel added AQ (=AQ·K). Next, at step 202, the amount AQ·K, that is, diesel oil, is added from the fuel adding valve 14 in accordance with the final amount of fuel added AQ.

[0074] Next, at step 203, the elapse of a certain time from the addition of the fuel is awaited. When that certain time has elapsed, the routine proceeds to step 204, where it is judged based on the output signals of the
temperature signals 21 and 22 if the temperature rise $\Delta T$ is lower than a reference value $\Delta T_0$. When it is judged that $\Delta T \geq \Delta T_0$, the routine proceeds to step 207, where $\Sigma \text{NO}_x$ is cleared, then the processing cycle is ended. When it is judged that $\Delta T < \Delta T_0$, the routine proceeds to step 205.

[0075] At step 205, the correction coefficient $K$ is increased by a certain value $\Delta K$, then at step 206 the elapse of a predetermined wait time, that is, the consumption of the added fuel, is awaited. When the wait time elapses, the routine proceeds through step 200 to step 201 and step 202, whereby a larger amount of fuel than the previous time is added.

[0076] FIG. 17 shows the fuel addition control in the case of detecting the air-fuel ratio A/F of the exhaust gas flowing out from the NO$_x$ storing catalyst 12 by an air-fuel ratio sensor 26 as shown in FIG. 2.

[0077] In the routine shown in FIG. 17, the only difference from the routine shown in FIG. 16 is step 204'. Therefore, only step 204' of the routine shown in FIG. 17 will be explained.

[0078] Referring to FIG. 17, at step 204', it is judged based on the output signal of the air-fuel ratio sensor 26 whether the air-fuel ratio A/F of the exhaust gas flowing out from the NO$_x$ storing catalyst 12 is about the stoichiometric air-fuel ratio. When it is judged that it is about the stoichiometric air-fuel ratio, the routine proceeds to step 207, while when it is judged that it is not about the stoichiometric air-fuel ratio, the routine proceeds to step 205.

LIST OF REFERENCE NUMERALS

[0079] 4 intake manifold
5 exhaust manifold
7 exhaust turbocharger
11 HC adsorbing and oxidation catalyst
12 NO$_x$ storing catalyst
14 fuel adding valve

Claims

1. An exhaust purification device for a compression ignition type internal combustion engine comprising fuel adding means (3) for adding particulate fuel into exhaust gas, an oxidation catalyst (13) arranged in an engine exhaust passage (52) downstream of the fuel adding means (3) for oxidizing hydrocarbons contained in the exhaust gas, and a NO$_x$ storing catalyst (12) arranged in the engine exhaust passage (13) downstream of the oxidation catalyst for storing NO$_x$ contained in the exhaust gas when the air-fuel ratio of the inflowing exhaust gas is lean and releasing the stored NO$_x$ when the air-fuel ratio in the inflowing exhaust gas becomes the stoichiometric air-fuel ratio or rich, wherein particulate fuel (53) is added from the fuel adding means when making the air-fuel ratio of the exhaust gas flowing into the NO$_x$ storing catalyst (12) rich to make the NO$_x$ storing catalyst release NO$_x$, characterized in the oxidation catalyst being a HC adsorbing and oxidation catalyst (11) for adsorbing and oxidizing hydrocarbons contained in the exhaust gas, the amount of addition of particulate fuel (53) added from the fuel adding means is set to an amount whereby the air-fuel ratio of the exhaust gas flowing into the HC adsorbing and oxidation catalyst (11) becomes a rich air-fuel ratio smaller than the rich air-fuel ratio when flowing into the NO$_x$ storing catalyst (12), and after the added particulate fuel (53) is adsorbed at the HC adsorbing and oxidation catalyst (11), the majority of the adsorbed fuel is oxidized in the HC adsorbing and oxidation catalyst (11) and the air-fuel ratio of the exhaust gas flowing into the NO$_x$ storing catalyst (12) is made rich over a longer period than when the air-fuel ratio of the exhaust gas flowing into the HC adsorbing and oxidation catalyst (11) is made rich.

2. An exhaust purification device as set forth in claim 1, wherein an amount of particulate fuel (53) to be added from said fuel adding means for making the NO$_x$ storing catalyst (12) release NO$_x$ is set to an amount giving an air-fuel ratio of the exhaust gas flowing into the HC adsorbing and oxidation catalyst (11) about 1 to about 7 at the time of engine low speed, low load operation.

3. An exhaust purification device as set forth in claim 1, wherein the amount of particulate fuel (53) added from said fuel adding means (3) for making NO$_x$ storing catalyst (12) release NO$_x$ is reduced the higher the temperature of the HC adsorbing and oxidation catalyst (11).

4. An exhaust purification device as set forth in claim 1, wherein the amount of addition of particulate fuel (53) from said fuel adding means for making the NO$_x$ storing catalyst release NO$_x$ is reduced the greater the flow rate of the exhaust gas.

5. An exhaust purification device as set forth in claim 1, wherein the amount of addition of particulate fuel (53) from said fuel adding means for making the NO$_x$ storing catalyst release NO$_x$ is made smaller at the time of engine high speed, high load operation compared with the time of engine low speed, low load operation.

6. An exhaust purification device as set forth in claim 1, wherein the frequency of addition of particulate fuel (53) from said fuel adding means for making the NO$_x$ storing catalyst release NO$_x$ is higher the higher the engine load.
7. An exhaust purification device as set forth in claim 1, wherein particulate fuel (53) is added from said fuel adding means (3) to make the NOx storing catalyst (12) release NOx when the amount of NOx stored in the NOx storing catalyst (12) exceeds an allowable value, and the allowable value is made lower the higher the engine load.

8. An exhaust purification device as set forth in claim 1, wherein a precious metal catalyst (52) is carried on a base of said HC adsorbing and oxidation catalyst (11).

9. An exhaust purification device as set forth in claim 1, wherein a base of said HC adsorbing and oxidation catalyst (11) includes zeolite.

10. An exhaust purification device as set forth in claim 1, where said device comprises judging means for judging if the air-fuel ratio of the exhaust gas flowing out from the HC adsorbing and oxidation catalyst has become rich when particulate fuel is added into the exhaust gas to make the NOx storing catalyst (12) release NOx, and said fuel adding means adds (3) fuel of the amount necessary for making the air-fuel ratio of the exhaust gas flowing out from the HC adsorbing and oxidation catalyst (11) rich in accordance with the judgment of said judging means when making the NOx storing catalyst (12) release NOx.

11. An exhaust purification device as set forth in claim 10, wherein temperature sensors (21, 22) able to detect a temperature rise of exhaust gas flowing out from the HC adsorbing and oxidation catalyst (11) are arranged in the engine exhaust passage, and said judging means judges that the air-fuel ratio of the exhaust gas flowing out from the HC adsorbing and oxidation catalyst (11) has become rich when said temperature rise exceeds a reference value.

12. An exhaust purification device as set forth in claim 10, wherein an air-fuel ratio sensor able to detect the air-fuel ratio of the exhaust flowing out from the NOx storing catalyst (12) is arranged in the engine exhaust passage downstream of the NOx storing catalyst, and said judging means judges that the air-fuel ratio of the exhaust gas flowing out from the HC adsorbing and oxidation catalyst (11) has become rich when the air-fuel ratio of the exhaust gas detected by the air-fuel ratio sensor is substantially the stoichiometric air-fuel ratio.

13. An exhaust purification device as set forth in claim 11 or 12, wherein when said judging means judges that the air-fuel ratio of the exhaust gas flowing out from the HC adsorbing and oxidation catalyst (11) is not rich, said fuel adding means increases the amount of particulate fuel (53) added from the fuel adding means.

14. An exhaust purification device as set forth in claim 13, wherein when said judging means judges that the air-fuel ratio of the exhaust gas flowing out from the HC adsorbing and oxidation catalyst (11) is not rich, said fuel adding means increases the amount of particulate fuel (53) added from the fuel adding means when it is next judged that NOx should be released from the NOx storing catalyst (12).

15. An exhaust purification device as set forth in claim 1, wherein the NOx storing catalyst (12) is carried on a particulate filter (12a) for trapping and oxidizing particulate matter contained in the exhaust gas.

16. An exhaust purification device as set forth in claim 15, wherein the temperature of the particulate filter (12a) is raised under a lean air-fuel ratio of the exhaust gas when the amount of particulate matter deposited on the particulate filter exceeds an allowable amount and thereby the deposited particulate matter is removed by oxidation.

Patentansprüche


dadurc gehenezeichnet, dass der Oxidationska- talysator ein Kohlenwasserstoff-Adsorbtions- und Oxidationskatalysator (11) zum Adsorbieren und Oxidieren von in dem Abgas enthaltenen Kohlen- wasserstoffen ist, die Menge der Zugabe von tei- chenförmi- gen Brennstoff (53), der von der Brenn- stoffzubehörrichtung zugegeben wird, auf eine Menge festgesetzt ist, wodurch das Luft-Brennstoff-
Abgasreinigungsvorrichtung nach Anspruch 1, wo- 5 7

3. Abgasreinigungsvorrichtung nach Anspruch 1, wo- 10

die Menge des teilchenförmigen Brennstoffs (53), der von der Brennstoffzugabevorrichtung (3) zugegeben wird, um zu bewirken, dass der NOₓ-Lagerungskatalysator (12) NOₓ freisetzt, der in dem Kohlenwasserstoff-Adsorptions- und Oxidationskatalysator (11) fließenden Abgases über eine längere Zeitdauer fett gemacht wird, als wenn das Luft-Brennstoff-Verhältnis des in den Adsorptions- und Oxidationskatalysator (12) fließenden Abgases über eine längere Zeitdauer fett gemacht wird, als wenn die Maschine mit mittlerer Geschwindigkeit und geringer Belastung fährt, von etwa 1 bis etwa 7 ergibt.

4. Abgasreinigungsvorrichtung nach Anspruch 1, wo- 20

die Menge an Zugabe von teilchenförmigem Brennstoff (53) von der Brennstoffzugabevorrichtung, um zu bewirken, dass der NOₓ-Lagerungskatalysator NOₓ freisetzt, verringert wird, je höher die Temperatur des Kohlenwasserstoff-Adsorptions- und Oxidationskatalysators (11) ist.

5. Abgasreinigungsvorrichtung nach Anspruch 1, wo- 25

die Menge der Zugabe von teilchenförmigem Brennstoff (53) von der Brennstoffzugabevorrichtung, um zu bewirken, dass der NOₓ-Lagerungskatalysator NOₓ freisetzt, kleiner gemacht wird zu dem Zeitpunkt, zu dem die Maschine mit hoher Geschwindigkeit und der Menge des in den Adsorptions- und Oxidationskatalysator (12) NOₓ freisetzt, kleiner gemacht wird zu dem Zeitpunkt, zu dem die Maschine mit niedriger Geschwindigkeit und niedriger Bela-

6. Abgasreinigungsvorrichtung nach Anspruch 1, wo- 30

bei der Menge der Zugabe von teilchenförmigem Brennstoff (53) von der Brennstoffzugabevorrichtung, um zu bewirken, dass der NOₓ-Lagerungskatalysator NOₓ freisetzt, umso höher ist, je höher die Maschinenbelastung ist.

7. Abgasreinigungsvorrichtung nach Anspruch 1, wo- 35

die Menge der Zugabe von teilchenförmigem Brennstoff (53) von der Brennstoffzugabevorrichtung (3) zugegeben wird, um zu bewirken, dass der NOₓ-Lagerungskatalysator (12) NOₓ freisetzt, wenn die Menge an in dem NOₓ-Lagerungskatalysator (12) gelagertem NOₓ einen zulässigen Wert überschreitet, und der zuläs-

8. Abgasreinigungsvorrichtung nach Anspruch 1, wo- 40

die Menge der Zugabe von teilchenförmigem Brennstoff (53) von der Brennstoffzugabevorrichtung, um zu bewirken, dass der NOₓ-Lagerungskatalysator NOₓ freisetzt, umso höher ist, je höher die Maschinenbelastung ist.


15. Abgasreinigungsrichtung nach Anspruch 1, wobei der NO$_x$-Lagerungskatalysator (12) auf einem Teilchenfilter (12a) zum Abfangen und Oxidieren von in dem Abgas enthaltenen teilchenförmigen Material getragen wird.

16. Abgasreinigungsrichtung nach Anspruch 15, wobei die Temperatur des Teilchenfilters (12a) bei einem mageren Luft-Kraftstoff-Verhältnis des Abgases angehoben wird, wenn die Menge des auf dem Teilchenfilter abgelagerten teilchenförmigen Materials als eine zulässige Menge überschreitet, und durch das abgelagerte teilchenförmige Material durch Oxidation entfernt wird.

Revendications

1. Dispositif de purification d’échappement pour un moteur à combustion interne du type à allumage par compression comportant des moyens d’ajout de carburant (3) destinés à ajouter du carburant en particules dans les gaz d’échappement, un catalyseur d’oxydation (13) disposé dans un passage d’échappement de moteur (52) en aval des moyens d’ajout de carburant (3) afin d’oxyder des hydrocarbures contenus dans les gaz d’échappement, et un catalyseur de stockage de NO$_x$ (12) disposé dans le passage d’échappement de moteur (13) en aval du catalyseur d’oxydation afin de stocker des NO$_x$ contenus dans les gaz d’échappement lorsque le rapport air-carburant des gaz d’échappement qui s’écoulent en entrée est pauvre et de libérer les NO$_x$ stockés lorsque le rapport air-carburant dans les gaz d’échappement qui s’écoulent en entrée devient le rapport air-carburant stoechiométrique ou riche, du carburant en particules (53) étant ajouté par les moyens d’ajout de carburant en rendant riche le rapport air-carburant des gaz d’échappement s’écoulant dans le catalyseur de stockage de NO$_x$ (12) afin d’amener le catalyseur de stockage de NO$_x$ à libérer des NO$_x$ caractérisé en ce que le catalyseur d’oxydation est un catalyseur d’adsorption et d’oxydation de HC (11) destiné à adsorber et oxyder des hydrocarbures contenus dans les gaz d’échappement, la quantité d’addition de carburant en particules (53) ajouté par les moyens d’ajout de carburant est établie à une quantité où le rapport air-carburant des gaz d’échappement qui s’écoulent dans le catalyseur d’adsorption et d’oxydation de HC (11) devient un rapport air-carburant riche plus faible que le rapport air-carburant riche lors de l’écoulement dans le catalyseur de stockage de NO$_x$ (12), et une fois que le carburant en particules ajouté (53) est adsorbé au niveau du catalyseur d’adsorption et d’oxydation de HC (11), la majorité du carburant adsorbé est oxydée dans le catalyseur d’adsorption et d’oxydation de HC (11) et le rapport air-carburant des gaz d’échappement qui s’écoulent dans le catalyseur de stockage de NO$_x$ (12) est rendu riche sur une durée plus longue que quand le rapport air-carburant des gaz d’échappement qui s’écoulent dans le catalyseur d’adsorption et d’oxydation de HC (11) est rendu riche.

2. Dispositif de purification d’échappement selon la revendication 1, dans lequel une quantité de carburant en particules (53) devant être ajouté par lesdits moyens d’ajout de carburant (3) afin d’amener le catalyseur de stockage de NO$_x$ (12) à libérer des NO$_x$ est établie à une quantité donnant un rapport air-carburant des gaz d’échappement qui s’écoulent dans le catalyseur d’adsorption et d’oxydation de HC (11) d’environ 1 à environ 7 au moment du fonctionnement du moteur à faible régime et faible charge.

3. Dispositif de purification d’échappement selon la revendication 1, dans lequel la quantité de carburant en particules (53) ajouté par lesdits moyens d’ajout de carburant (3) afin d’amener le catalyseur de stockage de NO$_x$ (12) à libérer des NO$_x$ est réduite plus la température du catalyseur d’adsorption et d’oxydation de HC (11) est élevée.
4. Dispositif de purification d’échappement selon la revendication 1, dans lequel la quantité d’addition de carburant en particules (53) par lesdits moyens d’ajout de carburant (3) afin d’amener le catalyseur de stockage de NOₓ à libérer des NOₓ est réduite plus le débit des gaz d’échappement est élevé.

5. Dispositif de purification d’échappement selon la revendication 1, dans lequel la quantité d’addition de carburant en particules (53) par lesdits moyens d’ajout de carburant afin d’amener le catalyseur de stockage de NOₓ (12) à libérer des NOₓ est rendue plus petite au moment du fonctionnement du moteur à haut régime et forte charge comparée au moment du fonctionnement du moteur à faible régime et faible charge.

6. Dispositif de purification d’échappement selon la revendication 1, dans lequel la fréquence d’addition du carburant en particules (53) par lesdits moyens d’ajout de carburant afin d’amener le catalyseur de stockage de NOₓ à libérer des NOₓ est plus élevée plus la charge du moteur est élevée.

7. Dispositif de purification d’échappement selon la revendication 1, dans lequel du carburant en particules (53) par lesdits moyens d’ajout de carburant lorsque le catalyseur de stockage de NOₓ (12) à libérer des NOₓ a rendu la quantité de NOₓ stockée dans le catalyseur de stockage de NOₓ (12) plus petite au moment du fonctionnement du moteur à haut régime et forte charge comparée au moment du fonctionnement du moteur à faible régime et faible charge.

8. Dispositif de purification d’échappement selon la revendication 1, dans lequel du carburant (12) supporté sur une base dudit catalyseur d’adsorption et d’oxydation de HC (11) est de la zéolithe.

9. Dispositif de purification d’échappement selon la revendication 1, dans lequel un catalyseur à métal précieux (52) est supporté sur une base dudit catalyseur d’adsorption et d’oxydation de HC (11).

10. Dispositif de purification d’échappement selon la revendication 1, lequel dispositif comporte des moyens d’estimation destinés à estimer si le rapport air-carburant des gaz d’échappement qui s’écoutent hors du catalyseur d’adsorption et d’oxydation de HC est devenu riche lorsque ladite augmentation de température (21, 22) capables de détecter une augmentation de température des gaz d’échappement qui s’écoulent hors du catalyseur d’adsorption et d’oxydation de HC (11) sont disposés dans un passage d’échappement de moteur, et lesdits moyens d’estimation estiment que le rapport air-carburant d’adsorption d’oxydation de HC (11) est devenu riche lorsque ladite augmentation de température dépasse une valeur de référence.

11. Dispositif de purification d’échappement selon la revendication 10, dans lequel du catalyseur de stockage de NOₓ (12) à libérer des NOₓ.

12. Dispositif de purification d’échappement selon la revendication 10, dans lequel un capteur de rapport air-carburant capable de détecter le rapport air-carburant des gaz d’échappement s’écoulant hors du catalyseur de stockage de NOₓ (12) est disposé dans le passage d’échappement de moteur en amenant le catalyseur de stockage de NOₓ et lesdits moyens d’estimation estiment que le rapport air-carburant des gaz d’échappement qui s’écoulent hors du catalyseur d’adsorption et d’oxydation de HC (11) est devenu riche lorsque le rapport air-carburant des gaz d’échappement détecté par le capteur de rapport air-carburant est sensiblement le rapport air-carburant stoechiométrique.

13. Dispositif de purification d’échappement selon la revendication 11 ou 12, dans lequel, lorsque lesdits moyens d’estimation estiment que le rapport air-carburant des gaz d’échappement qui s’écoutent hors du catalyseur d’adsorption et d’oxydation de HC (11) n’est pas riche, lesdits moyens d’ajout de carburant augmentent la quantité du carburant en particules (53) ajouté par les moyens d’ajout de carburant.

14. Dispositif de purification d’échappement selon la revendication 13, dans lequel, lorsque lesdits moyens d’estimation estiment que le rapport air-carburant des gaz d’échappement qui s’écoutent hors du catalyseur d’adsorption et d’oxydation de HC (11) n’est pas riche, lesdits moyens d’ajout de carburant augmentent la quantité du carburant en particules (53) ajouté par les moyens d’ajout de carburant lorsque l’on estime ensuite que des NOₓ doivent être libérés par le catalyseur de stockage de NOₓ (12).

15. Dispositif de purification d’échappement selon la revendication 1, dans lequel le catalyseur de stockage de NOₓ (12) est supporté sur un filtre à particules (12a) destiné à piéger et oxyder de la matière en particules contenue dans les gaz d’échappement.

16. Dispositif de purification d’échappement selon la re-
vendication 15, dans lequel la température du filtre à particules (12a) est augmentée dans un rapport air-carburant pauvre des gaz d'échappement lorsque la quantité de matière en particules déposée sur le filtre à particules dépasse une valeur admissible et la matière en particules déposée est ainsi enlevée par oxydation.
Fig. 7

(A)

PARTICULATE FUEL ADSORPTION

CATALYST TEMPERATURE

(B)

PARTICULATE FUEL ADSORPTION

SPATIAL VELOCITY
Fig. 9

Air-fuel ratio A/F

Temperature rise $\Delta T$

Exhausted HC amount $G$

Rich time $Tr$ (msec)
Fig. 10

Drive Signal vs. Time

Amount Added

(A) Stoichiometric Air-Fuel Ratio

(B) Stoichiometric Air-Fuel Ratio

(C) Stoichiometric Air-Fuel Ratio
Fig. 11
(A)

(B)
Fig. 12

(A)

LEAN

A/F

RICH

\( \sum \text{NOX} \)

STOICHIOMETRIC AIR-FUEL RATIO

MAX

NX

TIME

(B)

LEAN

A/F

RICH

\( \sum \text{NOX} \)

STOICHIOMETRIC AIR-FUEL RATIO

MAX

NX

TIME
Fig. 15

1. ADDITION PROCESSING
2. CALCULATE AQ
3. ADD DIESEL OIL
4. END
Fig. 16

1. Addition Processing
2. Calculate AQ
3. AQ ← AQ · K
4. Add Diesel Oil
5. Certain Time Elapsed?
6. ΔT < ΔT₀?
7. K ← K + ΔK
8. Wait Time Elapsed?
9. Σ NOX ← 0
10. End
Fig. 17

ADDITION PROCESSING

200

CALCULATE AQ

201

AQ ← AQ · K

202

ADD DIESEL OIL

203

CERTAIN TIME ELAPSED

? NO

204'

YES

SUBSTANTIALLY STOICHIOMETRIC AIR-FUEL RATIO

? NO

205

K ← K + ΔK

206

WAIT TIME ELAPSED

? YES

YES

207

Σ NOX ← 0

END
REFERENCES CITED IN THE DESCRIPTION

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