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(54) **AIR-FUEL RATIO CONTROL APPARATUS AND AIR-FUEL RATIO CONTROL METHOD FOR INTERNAL COMBUSTION ENGINE**

VORRICHTUNG ZUR STEUERUNG DES KRAFTSTOFF-LUFT-VERHÄLTNISSSES UND
VERFAHREN ZUR STEUERUNG DES KRAFTSTOFF-LUFT-VERHÄLTNISSSES IN EINEM
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RAPPORT AIR-CARBURANT POUR MOTEUR À COMBUSTION INTERNE

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Description

BACKGROUND OF THE INTENTION

1. Field of the Invention

[0001] The invention relates to an air-fuel ratio control apparatus.

2. Description of the Related Art

[0002] Japanese Patent Application Publication No. 5-321721 (JP-A-5-321721) describes an example of an air-fuel ratio control apparatus that includes a linear air-fuel ratio sensor disposed upstream of a catalyst, and an oxygen sensor disposed downstream of the catalyst. The air-fuel ratio control apparatus controls an air-fuel ratio based on signals output from the two sensors. The linear air-fuel ratio sensor has a linear output characteristic in which an output linearly changes in proportion to the air-fuel ratio. The oxygen sensor outputs a signal according to the concentration of oxygen in gas. The oxygen sensor has an output characteristic in which the output signal from the oxygen sensor is inverted when the air-fuel ratio changes from a value leaner than a stoichiometric ratio to a value richer than the stoichiometric ratio, or from a value richer than the stoichiometric ratio to a value leaner than the stoichiometric ratio. In the air-fuel ratio control apparatus, feedback control on a fuel injection amount is executed so that the air-fuel ratio of exhaust gas flowing into the catalyst is equal to the stoichiometric air-fuel ratio, based on the output signal from the linear air-fuel ratio sensor.

[0003] In addition to the feedback control based on the output signal from the linear air-fuel ratio sensor (hereinafter, this feedback control will be referred to as "main feedback control"), another feedback control is executed to correct the fuel injection amount based on the output signal from the oxygen sensor (hereinafter, the feedback control will be referred to as "sub feedback control"). In the sub feedback control, a correction value is calculated based on a difference between the output signal from the oxygen sensor and a reference signal corresponding to the stoichiometric air-fuel ratio, and the output signal from the linear air-fuel ratio sensor is corrected using the correction value. The correction value indicates whether the air-fuel ratio of the exhaust gas flowing into the catalyst is leaner or richer than the stoichiometric air-fuel ratio. Thus, when the output signal from the linear air-fuel ratio sensor has a deviation, the deviation is corrected, and the fuel injection amount is controlled so that an actual air-fuel ratio approaches the stoichiometric air-fuel ratio.

[0004] When the air-fuel ratio of the ambient atmosphere around the catalyst is near the stoichiometric air-fuel ratio, the catalyst purifies exhaust gas most efficiently. The catalyst has oxygen storage capacity (OSC) for storing oxygen therein. When the air-fuel ratio of the exhaust gas flowing into the catalyst is leaner than stoichi-

ometric air-fuel ratio, the oxygen in the gaseous phase is taken and stored in the catalyst. On the other hand, when the air-fuel ratio of the exhaust gas flowing into the catalyst is richer than stoichiometric air-fuel ratio, the oxygen, which has been stored in the catalyst, is released from the catalyst into the gaseous phase. Thus, the catalyst maintains the air-fuel ratio of the ambient atmosphere at a value near the stoichiometric air-fuel ratio, by storing or releasing the oxygen according to the air-fuel ratio of the exhaust gas flowing into the catalyst.

[0005] The level of the oxygen storage capacity of the catalyst greatly influences the efficiency of purifying the exhaust gas. That is, even if the air-fuel ratio of the exhaust gas greatly deviates from the stoichiometric air-fuel ratio, or even if the air-fuel ratio oscillates with a large amplitude, the oxygen may be stored in, or released from the catalyst, and the catalyst may maintain the air-fuel ratio of the ambient atmosphere at a value near the stoichiometric air-fuel ratio to purify the exhaust gas if the level of the oxygen storage capacity of the catalyst is high. It is known that the level of the oxygen storage capacity of the catalyst is maintained at a high level when noble metal of the catalyst is activated by repeating the storage and release of oxygen in the catalyst. By executing the above-described feedback control on the fuel injection amount, the air-fuel ratio of the exhaust gas oscillates around the stoichiometric air-fuel ratio, and thus, the storage and release of oxygen may be repeated in the catalyst.

[0006] However, recently, it has been found that the air-fuel ratio of the exhaust gas flowing into the catalyst as well as the deterioration of the catalyst influences the decrease in the level of the oxygen storage capacity of the catalyst. More specifically, even when the air-fuel ratio of the exhaust gas oscillates around the stoichiometric air-fuel ratio, the level of the oxygen storage capacity of the catalyst may be decreased if the amplitude of the oscillation of the air-fuel ratio is small.

[0007] FIG. 1 is a graph showing the relation between the air-fuel ratio of the exhaust gas flowing into the catalyst, and the amount of oxygen that may be stored in the catalyst or the amount of oxygen that may be released from the catalyst. As shown in FIG. 1, as the air-fuel ratio becomes richer, i.e., as the air-fuel ratio decreases from the stoichiometric air-fuel ratio, the amount of oxygen that may be stored in the catalyst increases. On the other hand, as the air-fuel ratio becomes leaner, i.e., as the air-fuel ratio increases from the stoichiometric air-fuel ratio, the amount of oxygen that may be released from the catalyst increases. In other words, as the air-fuel ratio approaches the stoichiometric air-fuel ratio, the amount of oxygen that may be stored in the catalyst and the amount of oxygen that may be released from the catalyst decreases. Therefore, if the amplitude of the oscillation of the air-fuel ratio around the stoichiometric air-fuel ratio remains small, only a small amount of oxygen is repeatedly stored in, and released from the catalyst. As a result, the level of the oxygen storage capacity of the catalyst

remains low and the catalyst is stabilized.

[0008] In the above-described case, the level of the oxygen storage capacity is temporarily decreased. When the amplitude of the oscillation of the air-fuel ratio increases again, the level of the oxygen storage capacity of the catalyst is recovered. However, it takes time to sufficiently recover the level of the oxygen storage capacity. Thus, until the level of the oxygen storage capacity is sufficiently recovered, excessive emissions beyond the purification capacity of the catalyst are discharged into the atmosphere. By executing the above-described feedback control on the fuel injection amount using the linear air-fuel ratio sensor and the oxygen sensor, the air-fuel ratio of the exhaust gas is maintained at a value near the stoichiometric air-fuel ratio. However, there is a possibility that emissions may be discharged from the catalyst due to the decrease in the level of the oxygen storage capacity of the catalyst when the air-fuel ratio fluctuates to some extent.

[0009] Document JP 09222010 A discloses an air-fuel ratio control apparatus for an internal combustion engine that includes a catalyst. The air-fuel ratio is controlled according to this document by an air-fuel ratio control means, so that an air-fuel ratio of exhaust gas is oscillated alternately to the rich side and the lean side before the first catalyst is activated. The magnetite of the amplitude of an exhaust air-fuel ratio oscillated alternately to the rich side and the lean side is set by a set means according to the oxygen storage capacity of the catalyst. When the reverse frequency of the upper and lower sensor outputs is larger than a reference value, it is decided that the amplitude air-fuel ratio exceeds the oxygen storage capacity of the catalyst and thus, the amplitude is reduced. Further, the document discloses that the amplitude of a lower stream side sensor may serve as a value of a limit of the oxygen storage capacity of the catalyst.

Summary of the invention

[0010] It is the object underlying the invention to provide an air-fuel ratio control apparatus for an internal combustion engine that includes a catalyst which is able to suppress the discharge of exhaust gas emissions even when the level of the oxygen storage capacity of a catalyst is decreased.

[0011] This object is solved by the features of claim 1.

[0012] According to the invention an air-fuel ratio control apparatus for an internal combustion engine includes a catalyst, disposed in an exhaust passage, which has oxygen storage capacity. The air-fuel ratio control apparatus according to the first aspect includes: fuel injection amount control means for controlling an amount of fuel injected to the internal combustion engine so that an air-fuel ratio of exhaust gas flowing into the catalyst oscillates around a stoichiometric air-fuel ratio; oxygen storage capacity estimation means for estimating a level of the oxygen storage capacity of the catalyst; and amplitude reduction means for reducing an amplitude of the air-fuel

ratio of the exhaust gas which oscillates around the stoichiometric air-fuel ratio when it is estimated that the level of the oxygen storage capacity of the catalyst is lower than a predetermined reference capacity.

[0013] The air-fuel ratio control apparatus for the internal combustion engine may include an air-fuel ratio sensor that outputs a signal according to the air-fuel ratio of the exhaust gas flowing into the catalyst. The oxygen storage capacity estimation means may estimate that the level of the oxygen storage capacity of the catalyst is lower than the predetermined reference capacity when the amplitude of the signal output from the air-fuel ratio sensor remains smaller than a predetermined value more than a prescribed period.

[0014] The fuel injection amount control means may control the amount of fuel injected to the internal combustion engine by executing a feedback control on the air-fuel ratio based on a difference between the signal output from the air-fuel ratio sensor and a reference value corresponding to the stoichiometric air-fuel ratio. The amplitude reduction means may reduce the amplitude of the air-fuel ratio of the exhaust gas which oscillates around the stoichiometric air-fuel ratio on the feedback control by reducing a gain used to correct the amount of fuel injected to the internal combustion engine or by limiting a correction amount based on the difference between the signal output from the air-fuel ratio sensor and the reference value corresponding to the stoichiometric air-fuel ratio.

[0015] The fuel injection amount control means may control the amount of fuel injected to the internal combustion engine by executing a feedback control on the air-fuel ratio based on a difference between the signal output from the air-fuel ratio sensor and a reference value corresponding to the stoichiometric air-fuel ratio while the fuel injection amount control means corrects the amount of fuel injected to the internal combustion engine based on a difference between the output signal from the oxygen sensor and the reference value corresponding to the stoichiometric air-fuel ratio. The amplitude reduction means may reduce the amplitude of the oscillation of the air-fuel ratio of the exhaust gas which oscillates around the stoichiometric air-fuel ratio by reducing a gain used to correct the amount of fuel injected to the internal combustion engine or by limiting a correction amount based on the difference between the signal output from the oxygen sensor and the reference value corresponding to the stoichiometric air-fuel ratio.

[0016] The air-fuel ratio control apparatus for the internal combustion engine may further include amplitude reduction stop means for stopping reducing the amplitude of the air-fuel ratio of the exhaust gas which oscillates around the stoichiometric air-fuel ratio when one of fuel supply cutoff control and fuel injection amount increase control is executed.

[0017] The air-fuel ratio control apparatus for the internal combustion engine may further include execution frequency increase means for increasing at least one of an

execution frequency of the fuel supply cutoff control and an execution frequency of the fuel injection amount increase control when the amplitude of the air-fuel ratio of the exhaust gas which oscillates around the stoichiometric air-fuel ratio remains reduced more than a prescribed period.

[0018] The execution frequency increase means may increase at least one of an execution frequency of the fuel supply cutoff control and an execution frequency of the fuel injection amount increase control when an accumulated amount of air taken into the internal combustion engine exceeds a prescribed amount after the amplitude of the air-fuel ratio of the exhaust gas which oscillates around the stoichiometric air-fuel ratio is reduced.

BRIEF DESCRIPTION OF THE DRAWINGS

[0019] The foregoing and further objects, features and advantages of the invention will become apparent from the following description of example embodiments with reference to the accompanying drawings, wherein like numerals are used to represent like elements and wherein:

FIG. 1 is a graph showing a relation between the air-fuel ratio of exhaust gas flowing into a catalyst, and the amount of oxygen that may be stored in the catalyst or the amount of oxygen that may be released from the catalyst;

FIG. 2 is a schematic diagram showing an internal combustion engine system in which an air-fuel ratio control apparatus according to an embodiment of the invention is employed; and

FIG. 3 is the flowchart of the routine of an air-fuel ratio control executed in the embodiment of the invention.

DETAILED DESCRIPTION OF THE EMBODIMENTS

[0020] Hereinafter, an embodiment of the invention will be described with reference to the accompanying drawings. FIG. 2 is a schematic diagram showing an internal combustion engine system that includes an air-fuel ratio control apparatus according to the embodiment of the invention. As shown in FIG. 2, an internal combustion engine 2 is connected to an exhaust passage 4. Two catalysts 6 and 8, which purify pollutants (NO_x, CO, and HC) in exhaust gas, are disposed in the exhaust passage 4. At least the catalyst 6 on an upstream side has oxygen storage capacity. It is to be understood that "storage" used herein means retention of a substance (solid, liquid, gas molecules) in the form of at least one of adsorption, adhesion, absorption, trapping, occlusion, and others. The catalyst 6 on the upstream side is disposed close to an exhaust manifold (not shown). The catalyst 8 on a downstream side is disposed under the floor of a vehicle. A linear air-fuel ratio sensor 12 is installed upstream of the catalyst 6. An oxygen sensor 14 is installed down-

stream of the catalyst 6. The linear air-fuel ratio sensor 12 has a linear output characteristic in which an output linearly changes in proportion to an air-fuel ratio. The oxygen sensor 14 outputs a signal according to the concentration of oxygen in the exhaust gas. The oxygen sensor 14 has an output characteristic in which the output signal from the oxygen sensor is inverted when the air-fuel ratio changes from a value leaner than the stoichiometric ratio to a value richer than the stoichiometric ratio, or from a value richer than the stoichiometric ratio to a value leaner than the stoichiometric ratio.

[0021] In the internal combustion engine system, an ECU (Electronic Control Unit) 10 is provided. The ECU 10 totally controls the operation of the entire internal combustion engine system. The above-described linear air-fuel ratio sensor 12 and the oxygen sensor 14 are connected to the ECU 10. The ECU 10 executes a feedback control on a fuel injection amount so that the air-fuel ratio of the exhaust gas flowing into the catalyst 6 is equal to the stoichiometric air-fuel ratio, based on the signals output from the linear air-fuel ratio sensor 12 and the oxygen sensor 14. Hereinafter, this feedback control will be referred to as "air-fuel ratio feedback control".

[0022] The air-fuel ratio feedback control executed by the ECU 10 includes a main feedback control and a sub feedback control. In the main feedback control, the fuel injection amount is corrected based on a difference between the output signal from the linear air-fuel ratio sensor 12 and the reference value corresponding to stoichiometric air-fuel ratio. In the sub feedback control, the fuel injection amount is corrected based on a difference between the output signal from the oxygen sensor 14 and a reference value corresponding to the stoichiometric air-fuel ratio. The air-fuel ratio feedback control using the linear air-fuel ratio sensor 12 and the oxygen sensor 14 is a known method. Therefore, the detailed description thereof will be omitted in this specification.

[0023] By executing the air-fuel ratio feedback control, the air-fuel ratio of the exhaust gas is maintained at a value near the stoichiometric air-fuel ratio. However, the amount of oxygen that may be stored in the catalyst 6 and the amount of oxygen that may be released from the catalyst 6 are decreased, and thus, the level of the oxygen storage capacity of the catalyst 6 is decreased. As a result, when the air-fuel ratio fluctuates to some extent, emissions are discharged from the catalyst 6. Accordingly, the ECU 10 executes a control for forcibly reducing the amplitude of the oscillation of the air-fuel ratio (hereinafter, referred to as "amplitude reduction control") under a predetermined condition when the air-fuel ratio feedback control is being executed. Because the amplitude reduction control forcibly reduces the amplitude of the oscillation of the air-fuel ratio, it is possible to avoid a situation where the air-fuel ratio is so rich that the amount of oxygen that needs to be released from the catalyst 6 exceeds the amount of oxygen that may be released from the catalyst 6, or the air-fuel ratio is so lean that the amount of oxygen that needs to be stored in the

catalyst 6 exceeds the amount of oxygen that may be stored in the catalyst 6.

[0024] Hereinafter, the amplitude reduction control executed by the ECU 10 in the embodiment will be described. The amplitude reduction control is executed in the routine of the air-fuel ratio control shown in a flowchart in FIG. 3. In the routine shown in FIG. 3, in the first step, i.e., in step S2, it is determined whether the air-fuel ratio feedback control is being executed. When the air-fuel ratio feedback control is not being executed, the routine ends without executing the amplitude reduction control.

[0025] When the air-fuel ratio feedback control is being executed, a determination process in step S4 is executed. In step S4, it is determined whether the amplitude of the output signal from the oxygen sensor 14 is equal to or below a predetermined reference value. When the air-fuel ratio of the exhaust gas flowing into the catalyst 6 approaches the stoichiometric air-fuel ratio due to the air-fuel ratio feedback control, and the amplitude of the oscillation of the air-fuel ratio remains small, the amount of oxygen that may be released from the catalyst 6 and the amount of oxygen that may be stored in the catalyst 6 are decreased. This decreases the change in the concentration of oxygen in the exhaust gas that has passed through the catalyst 6, and accordingly decreases the amplitude of the output signal from the oxygen sensor 14 disposed downstream of the catalyst 6. Thus, the level of the oxygen storage capacity of the catalyst 6 is estimated based on the amplitude of the output signal from the oxygen sensor 14. That is, by comparing the amplitude of the output signal from the oxygen sensor 14 with the reference value, it is accurately determined whether the level of the oxygen storage capacity of the catalyst 6 is decreased.

[0026] When it is determined that the amplitude of the output signal from the oxygen sensor 14 is equal to or below the reference value in step S4, it is determined that the level of the oxygen storage capacity of the catalyst 6 is decreased. In this case, the amplitude reduction control is executed in step S6. When the amplitude of the output signal from the oxygen sensor 14 is larger than the reference value, the determination processes in steps S2 and S4 are repeatedly executed until the condition in step S2 (i.e., the condition that the air-fuel ratio feedback control is being executed) is not satisfied, or the condition in step S4 (i.e., the condition that the amplitude of the output signal from the oxygen sensor 14 is equal to or below the reference value) is satisfied.

[0027] In the amplitude reduction control executed in step S6, a gain used to correct the fuel injection amount based on the difference between the output signal from the linear air-fuel ratio sensor 12 and the reference value corresponding to the stoichiometric air-fuel ratio in the main feedback (hereinafter, this gain will be referred to as "main feedback correction gain") is reduced. The main feedback correction gain is a fixed value. In the amplitude reduction control, the main feedback correction gain is multiplied by a correction coefficient that is smaller than

1. By reducing the main feedback correction gain, it is possible to efficiently reduce the amplitude of the oscillation of the air-fuel ratio of the exhaust gas flowing into the catalyst 6.

[0028] In step S8, it is determined whether the air-fuel ratio feedback control is still being executed. When the air-fuel ratio feedback control is interrupted, the processes in steps S10, S12, and S14 are skipped, and a process in step S16 is executed. In step S16, the amplitude reduction control on the air-fuel ratio is stopped, and the main feedback correction gain, which is reduced in step S6, is returned to a normal value.

[0029] When the air-fuel ratio feedback control is still being executed, the process in step S16 is executed on the condition that fuel supply is cut off. By cutting off the fuel supply, the exhaust gas that contains a large amount of oxygen, i.e., the exhaust gas at a lean air-fuel ratio flows into the catalyst 6, and thus the level of the oxygen storage capacity of the catalyst 6 is recovered. After the level of the oxygen storage capacity of the catalyst 6 is recovered, the oxygen may be stored in, and released from the catalyst 6 even when the air-fuel ratio fluctuates to some extent. Accordingly, in this case, the amplitude reduction control is stopped, and therefore the main feedback correction gain is returned to the normal value to use the oxygen storage capacity of the catalyst 6 to the fullest extent. In step S14, it is determined whether the fuel supply is cut off. More specifically, in step S14, the fuel supply continues to be cut off during a prescribed period. The prescribed period is a sufficient time period during which the level of the oxygen storage capacity of the catalyst 6 is recovered by the inflow of the exhaust gas at a lean air-fuel ratio.

[0030] When the air-fuel ratio feedback control is still being executed, a determination process in step S10 is executed before a determination process in step S14 is executed. In step S10, an elapsed time after the main feedback correction gain is reduced by the amplitude reduction control is measured. Then, it is determined whether a predetermined time has elapsed after the main feedback correction gain is reduced.

[0031] When the predetermined time has elapsed after the main feedback correction gain is reduced, a process in step S12 is executed. In step S12, the frequency of execution of a fuel supply cutoff control, and a period during which the fuel supply cutoff control is executed are increased by relaxing a condition for executing the fuel supply cutoff control, and tightening a condition for ending the fuel supply cutoff control (i.e., a condition for restarting the fuel supply). By increasing the frequency of execution of the fuel supply cutoff control, and the period during which the fuel supply cutoff control is executed, the condition in step S14 (i.e., the condition that the fuel supply is cut off) is quickly satisfied, and accordingly, the air-fuel ratio feedback control is quickly returned to the normal air-fuel ratio feedback control to use the oxygen storage capacity of the catalyst 6 to the fullest extent. When the predetermined time has not elapsed after

the main feedback correction gain is reduced, the process in step S12 is skipped, and a determination process in step S14 is executed.

[0032] In the embodiment, the air-fuel ratio control is executed according to the above-described routine, along with the air-fuel ratio feedback control. In the air-fuel ratio control according to the above-described routine, when the level of the oxygen storage capacity of the catalyst 6 is decreased, it is possible to forcibly reduce the amplitude of the oscillation of the air-fuel ratio that oscillates around the stoichiometric air-fuel ratio. Thus, it is possible to avoid the situation where the air-fuel ratio is so rich that the amount of oxygen that needs to be released from the catalyst 6 exceeds the amount of oxygen that may be released from the catalyst 6, or the air-fuel ratio is so lean that the amount of oxygen that needs to be stored in the catalyst 6 exceeds the amount of oxygen that may be stored in the catalyst 6. Accordingly, the discharge of emissions from the catalyst 6 is suppressed when the air-fuel ratio feedback control is executed.

[0033] In the embodiment, when the ECU 10 executes the air-fuel ratio feedback control, "the fuel injection amount control means" according to the invention is implemented. When the ECU 10 executes the process in step S4 in the routine shown in FIG. 3, "the oxygen storage capacity estimation means" according to the invention is implemented. When the ECU 10 executes the process in step S6, "the amplitude reduction means" according to the invention is implemented.

[0034] In the embodiment, when the ECU 10 executes the processes in steps S14 and S16, "the amplitude reduction stop means" according to the invention is implemented. When the ECU 10 executes the processes in steps S10 and S12, "the execution frequency increase means" according to the invention is implemented.

[0035] Although the embodiment of the invention has been described, the invention is not limited to the embodiment. Various modifications may be made within the scope of the invention. For example, the following modifications may be made.

[0036] In the amplitude reduction control on the air-fuel ratio, a gain used to correct the fuel injection amount based on the difference between the output signal from the oxygen sensor 14 and the reference value corresponding to the stoichiometric air-fuel ratio in the sub feedback control (hereinafter, this gain will be referred to as "sub feedback correction gain") may be reduced. In this manner as well, "the amplitude reduction means" according to the invention may be implemented. Alternatively, both of the main feedback correction gain and the sub feedback correction gain may be reduced.

[0037] In the amplitude reduction control, a limit may be imposed on a correction amount by which the fuel injection amount is corrected based on the difference between the output signal from the linear air-fuel ratio sensor 12 and the reference value corresponding to the stoichiometric air-fuel ratio in the main feedback control. Al-

ternatively, a limit may be imposed on a correction amount by which the fuel injection amount is corrected based on the difference between the output signal from the oxygen sensor 14 and the reference value corresponding to the stoichiometric air-fuel ratio in the sub feedback control.

[0038] When the fuel injection amount is increased, the air-fuel ratio of the exhaust gas flowing into the catalyst 6 is made rich. The release of the oxygen from the catalyst 6 is promoted by the inflow of the exhaust gas at a rich air-fuel ratio. Thus, the level of the oxygen storage capacity of the catalyst 6 is expected to be recovered. Accordingly, the amplitude reduction control may be stopped on the condition that the fuel supply is cut off, or the fuel injection amount is increased during acceleration or the like. That is, when the predetermined time has elapsed after the amplitude reduction control on the air-fuel ratio is started, at least one of the frequency of execution of the fuel supply cutoff control and the frequency of execution of the fuel injection amount increase control may be increased.

[0039] It may be determined whether at least one of the frequency of execution of the fuel supply cutoff control and the frequency of execution of the fuel injection amount increase control needs to be increased, based on an accumulated value obtained by accumulating values of the amount of air taken into the internal combustion engine (hereinafter, referred to as "intake air amount") after the amplitude reduction control on the air-fuel ratio is started. More specifically, when the accumulated value of the intake air amount exceeds a predetermined value, at least one of the frequency of execution of the fuel supply cutoff control and the frequency of execution of the fuel injection amount increase control may be increased. In this manner as well, "the execution frequency increase means" according to the invention may be implemented.

[0040] The level of the oxygen storage capacity of the catalyst 6 may be estimated based on the output signal from the linear air-fuel ratio sensor 12. The output signal from the linear air-fuel ratio sensor 12 indicates the air-fuel ratio of the exhaust gas flowing into the catalyst 6. Accordingly, when the amplitude of the output signal from the linear air-fuel ratio sensor 12 remains small, only a small amount of oxygen is repeatedly stored in, and released from the catalyst 6. Therefore, it is estimated that the level of the oxygen storage capacity of the catalyst 6 is decreased. In this case, when the amplitude of the output signal from the linear air-fuel ratio sensor 12 remains smaller than a predetermined value for a period longer than a prescribed period, it may be estimated that the level of the oxygen storage capacity of the catalyst 6 is decreased, and the amplitude of the oscillation of the air-fuel ratio may be reduced. In this manner as well, "the oxygen storage capacity estimation means" according to the invention may be implemented.

[0041] The sensor disposed upstream of the catalyst 6 is not limited to the linear air-fuel ratio sensor. Any air-fuel ratio sensor that outputs a signal according to the

air-fuel ratio of the exhaust gas flowing into the catalyst may be employed. For example, the same oxygen sensor as that disposed downstream of the catalyst 6 in the embodiment may be disposed upstream of the catalyst 6 as an air-fuel ratio sensor.

[0042] The invention may be applied to an internal combustion engine system in which the air-fuel ratio sensor is provided upstream of the catalyst 6, but the oxygen sensor is not provided downstream of the catalyst 6, that is, an internal combustion engine system where the air-fuel ratio feedback control is executed by using only the main feedback control. In this case, the level of the oxygen storage capacity of the catalyst 6 may be estimated based on the output signal from the air-fuel ratio sensor disposed upstream of the catalyst 6 as described above.

[0043] While the invention has been described with reference to example embodiments thereof, it is to be understood that the invention is not limited to the described embodiments or constructions. To the contrary, the invention is intended to cover various modifications and equivalent arrangements. In addition, while the various elements of the example embodiments are shown in various combinations and configurations, other combinations and configurations, including more, less or only a single element, are also within the scope of the invention according to the claims.

Claims

1. An air-fuel ratio control apparatus for an internal combustion engine (2) that includes a catalyst (6), disposed in an exhaust passage, which has oxygen storage capacity, **characterized by** comprising:

fuel injection amount control means for controlling an amount of fuel injected to the internal combustion engine (2) so that an air-fuel ratio of exhaust gas flowing into the catalyst (6) oscillates around a stoichiometric air-fuel ratio;
 oxygen storage capacity estimation means (10) estimating a level of the oxygen storage capacity of the catalyst (6),
 amplitude reduction means for reducing an amplitude of the air-fuel ratio of the exhaust gas which oscillates around the stoichiometric air-fuel ratio when it is estimated that the level of the oxygen storage capacity of the catalyst (6) is lower than a predetermined reference capacity,
 an air-fuel ratio sensor (12) that outputs a signal according to the air-fuel ratio of the exhaust gas flowing into the catalyst (6),
 wherein the oxygen storage capacity estimation means (10) estimates that the level of the oxygen storage capacity of the catalyst (6) is lower than the predetermined reference capacity when the amplitude of the signal output from the

air-fuel ratio sensor (12) remains smaller than a predetermined value more than a prescribed period.

2. The air-fuel ratio control apparatus for the internal combustion engine (2) according to claim 1, further comprising
 an oxygen sensor (14) that outputs a signal according to a concentration of oxygen in the exhaust gas that has passed through the catalyst (6),
 wherein the oxygen storage capacity estimation means (10) estimates that the level of the oxygen storage capacity is lower than the predetermined reference capacity when the amplitude of the signal output from the oxygen sensor (14) is smaller than a predetermined value.
3. The air-fuel ratio control apparatus for the internal combustion engine (2) according to claim 1 or 2, further comprising
 an air-fuel ratio sensor (12) that outputs a signal according to the air-fuel ratio of the exhaust gas flowing into the catalyst (6),
 wherein the fuel injection amount control means (10) controls the amount of fuel injected to the internal combustion engine (2) by executing a feedback control on the air-fuel ratio based on a difference between the signal output from the air-fuel ratio sensor (12) and a reference value corresponding to the stoichiometric air-fuel ratio, and
 wherein the amplitude reduction means (10) reduces the amplitude of the air-fuel ratio of the exhaust gas which oscillates around the stoichiometric air-fuel ratio on the feedback control by reducing a gain used to correct the amount of fuel injected to the internal combustion engine (2) based on the difference between the signal output from the air-fuel ratio sensor (12) and the reference value corresponding to the stoichiometric air-fuel ratio.
4. The air-fuel ratio control apparatus for the internal combustion engine (2) according to claim 1 or 2, further comprising
 an air-fuel ratio sensor (12) that outputs a signal according to the air-fuel ratio of the exhaust gas flowing into the catalyst (6),
 wherein the fuel injection amount control means (10) controls the amount of fuel injected to the internal combustion engine (2) by executing a feedback control on the air-fuel ratio based on a difference between the signal output from the air-fuel ratio sensor (12) and a reference value corresponding to the stoichiometric air-fuel ratio, and
 wherein the amplitude reduction means (10) reduces the amplitude of the air-fuel ratio of the exhaust gas which oscillates around the stoichiometric air-fuel ratio on the feedback control by limiting a correction amount based on the difference between the signal

output from the air-fuel ratio sensor (12) and the reference value corresponding to the stoichiometric air-fuel ratio.

5. The air-fuel ratio control apparatus for the internal combustion engine (2) according to claim 1 or 2, further comprising:

an air-fuel ratio sensor (12) that outputs a signal according to the air-fuel ratio of the exhaust gas flowing into the catalyst (6); and

an oxygen sensor (14) that outputs a signal according to a concentration of oxygen in the exhaust gas that has passed through the catalyst (6),

wherein the fuel injection amount control means (10) controls the amount of fuel injected to the internal combustion engine (2) by executing a feedback control on the air-fuel ratio based on a difference between the signal output from the air-fuel ratio sensor (12) and a reference value corresponding to the stoichiometric air-fuel ratio while the fuel injection amount control means (10) corrects the amount of fuel injected to the internal combustion engine (2) based on a difference between the output signal from the oxygen sensor (12) and the reference value corresponding to the stoichiometric air-fuel ratio, and

wherein the amplitude reduction means (10) reduces the amplitude of the oscillation of the air-fuel ratio of the exhaust gas which oscillates around the stoichiometric air-fuel ratio by reducing a gain used to correct the amount of fuel injected to the internal combustion engine (2) based on the difference between the signal output from the oxygen sensor (12) and the reference value corresponding to the stoichiometric air-fuel ratio.

6. The air-fuel ratio control apparatus for the internal combustion engine (2) according to claim 1 or 2, further comprising:

an air-fuel ratio sensor (12) that outputs a signal according to the air-fuel ratio of the exhaust gas flowing into the catalyst (6); and

an oxygen sensor (12) that outputs a signal according to a concentration of oxygen in the exhaust gas that has passed through the catalyst (6),

wherein the fuel injection amount control means (10) controls the amount of fuel injected to the internal combustion engine (2) by executing a feedback control on the air-fuel ratio based on a difference between the signal output from the air-fuel ratio sensor (12) and a reference value corresponding to the stoichiometric air-fuel ratio

while the fuel injection amount control means (10) corrects the amount of fuel injected to the internal combustion engine (2) based on a difference between the output signal from the oxygen sensor (12) and the reference value corresponding to the stoichiometric air-fuel ratio, and

wherein the amplitude reduction means (10) reduces the amplitude of the oscillation of the air-fuel ratio of the exhaust gas which oscillates around the stoichiometric air-fuel ratio by limiting a correction amount based on the difference between the signal output from the oxygen sensor (12) and the reference value corresponding to the stoichiometric air-fuel ratio.

7. The air-fuel ratio control apparatus for the internal combustion engine (2) according to any one of claims 1 to 6, further comprising

amplitude reduction stop means (10) for stopping reducing the amplitude of the air-fuel ratio of the exhaust gas which oscillates around the stoichiometric air-fuel ratio when one of fuel supply cutoff control and fuel injection amount increase control is executed.

8. The air-fuel ratio control apparatus for the internal combustion engine (2) according to claim 7, further comprising

execution frequency increase means (10) for increasing at least one of an execution frequency of the fuel supply cutoff control and an execution frequency of the fuel injection amount increase control when the amplitude of the air-fuel ratio of the exhaust gas which oscillates around the stoichiometric air-fuel ratio remains reduced more than a prescribed period.

9. The air-fuel ratio control apparatus for the internal combustion engine (2) according to claim 7, further comprising

execution frequency increase means (10) for increasing at least one of an execution frequency of the fuel supply cutoff control and an execution frequency of the fuel injection amount increase control when an accumulated amount of air taken into the internal combustion engine (2) exceeds a prescribed amount after the amplitude of the air-fuel ratio of the exhaust gas which oscillates around the stoichiometric air-fuel ratio is reduced.

Patentansprüche

1. Luftkraftstoffverhältnissteuergerät für eine Brennkraftmaschine (2), die einen Katalysator (6), der in einem Abgasdurchgang angeordnet ist, aufweist, welcher eine Sauerstoffspeicherkapazität aufweist,

gekennzeichnet durch:

- eine Kraftstoffeinspritzmengensteuereinrichtung zum Steuern einer Menge von Kraftstoff, die in die Brennkraftmaschine (2) eingespritzt ist, so dass ein Luftkraftstoffverhältnis des Abgases, das in den Katalysator (6) strömt, um ein stöchiometrisches Luftkraftstoffverhältnis herum oszilliert;
- eine Sauerstoffspeicherkapazitätsschätzeinrichtung (10), die ein Niveau der Sauerstoffspeicherkapazität des Katalysators schätzt,
- eine Amplitudenverringereinrichtung zum Verringern einer Amplitude des Luftkraftstoffverhältnisses des Abgases, das um das stöchiometrische Luftkraftstoffverhältnis herum oszilliert, wenn bestimmt ist, dass das Niveau der Sauerstoffspeicherkapazität des Katalysators (6) niedriger als eine vorbestimmte Referenzkapazität ist,
- einen Luftkraftstoffverhältnissensor (12), der ein Signal gemäß dem Luftkraftstoffverhältnis des Abgases ausgibt, das in den Katalysator (6) strömt,
- wobei die Sauerstoffspeicherkapazitätsschätzeinrichtung (10) schätzt, dass das Niveau der Sauerstoffspeicherkapazität des Katalysators (6) niedriger als die vorbestimmte Referenzkapazität ist, wenn die Amplitude des Signals, das von dem Luftkraftstoffverhältnissensor (12) ausgegeben ist, länger als eine vorgeschriebene Zeitdauer niedriger als ein vorbestimmter Wert bleibt.
2. Luftkraftstoffverhältnissteuergerät für die Brennkraftmaschine (2) nach Anspruch 1, ferner mit einem Sauerstoffsensor (14), der ein Signal gemäß einer Konzentration von Sauerstoff in dem Abgas ausgibt, das durch den Katalysator (6) getreten ist, wobei die Sauerstoffspeicherkapazitätsschätzeinrichtung (10) schätzt, dass das Niveau der Sauerstoffspeicherkapazität niedriger als die vorbestimmte Referenzkapazität ist, wenn die Amplitude des Signals, das von dem Sauerstoffsensor (14) ausgegeben ist, niedriger als ein vorbestimmter Wert ist.
3. Luftkraftstoffverhältnissteuergerät für die Brennkraftmaschine (2) nach Anspruch 1 oder 2, ferner mit einem Luftkraftstoffverhältnissensor (12), der ein Signal gemäß dem Luftkraftstoffverhältnis des Abgases ausgibt, das in den Katalysator (6) strömt, wobei die Kraftstoffeinspritzmengensteuereinrichtung (10) die Menge von Kraftstoff steuert, die in die Brennkraftmaschine (2) eingespritzt ist, durch ein Ausführen einer Regelung auf das Luftkraftstoffverhältnis basierend auf einer Differenz zwischen dem Signal, das von dem Luftkraftstoffverhältnissensor (12) ausgegeben ist, und einem Referenzwert, der dem

stöchiometrischen Luftkraftstoffverhältnis entspricht, und

wobei die Amplitudenverringereinrichtung (10) die Amplitude des Luftkraftstoffverhältnisses des Abgases, die um das stöchiometrische Luftkraftstoffverhältnis herum oszilliert, an der Regelung durch ein Verringern einer Zunahme verringert, die verwendet ist, um die Menge von Kraftstoff zu korrigieren, die in die Brennkraftmaschine (2) eingespritzt ist, basierend auf der Differenz zwischen dem Signal, das von dem Luftkraftstoffverhältnissensor (12) ausgegeben ist, und dem Referenzwert, der dem stöchiometrischen Luftkraftstoffverhältnis entspricht.

4. Luftkraftstoffverhältnissteuergerät für die Brennkraftmaschine (2) nach Anspruch 1 oder 2, ferner mit einem Luftkraftstoffverhältnissensor (12), der ein Signal gemäß dem Luftkraftstoffverhältnis des Abgases ausgibt, das in den Katalysator (6) strömt, wobei die Kraftstoffeinspritzmengensteuereinrichtung (10) die Menge von Kraftstoff steuert, die in die Brennkraftmaschine (2) eingespritzt ist, durch ein Ausführen einer Regelung auf das Luftkraftstoffverhältnis basierend auf einer Differenz zwischen dem Signal, das von dem Luftkraftstoffverhältnissensor (12) ausgegeben ist, und einem Referenzwert, der dem stöchiometrischen Luftkraftstoffverhältnis entspricht, und
- wobei die Amplitudenverringereinrichtung (10) die Amplitude des Luftkraftstoffverhältnisses des Abgases, die um das stöchiometrische Luftkraftstoffverhältnis herum oszilliert, an der Regelung durch ein Begrenzen eines Korrekturbetrags verringert, basierend auf der Differenz zwischen dem Signal, das von dem Luftkraftstoffverhältnissensor (12) ausgegeben ist, und dem Referenzwert, der dem stöchiometrischen Luftkraftstoffverhältnis entspricht.
5. Luftkraftstoffverhältnissteuergerät für die Brennkraftmaschine (2) nach Anspruch 1 oder 2, ferner mit einem Luftkraftstoffverhältnissensor (12), der ein Signal gemäß dem Luftkraftstoffverhältnis des Abgases ausgibt, das in den Katalysator (6) strömt; und einem Sauerstoffsensor (14), der ein Signal gemäß einer Konzentration von Sauerstoff in dem Abgas ausgibt, das durch den Katalysator (6) getreten ist, wobei die Kraftstoffeinspritzmengensteuereinrichtung (10) die Menge von Kraftstoff, die in die Brennkraftmaschine (2) eingespritzt ist, durch ein Ausführen einer Regelung auf das Luftkraftstoffverhältnis steuert, basierend auf einer Differenz zwischen dem Signal, das von dem Luftkraftstoffverhältnissensor (12) ausgegeben ist, und einem Referenzwert, der dem stöchiometrischen Luftkraftstoffverhältnis entspricht, während die Kraftstoffeinspritzmengensteuereinrichtung (10) die Menge von Kraftstoff, die in

die Brennkraftmaschine (2) eingespritzt ist, basierend auf einer Differenz zwischen dem Ausgabesignal von dem Sauerstoffsensor (12) und dem Referenzwert steuert, der dem stöchiometrischen Luftkraftstoffverhältnis entspricht, und
 wobei die Amplitudenverringereinrichtung (10) die Amplitude der Oszillation des Luftkraftstoffverhältnisses des Abgases, die um das stöchiometrische Luftkraftstoffverhältnis herum oszilliert, durch ein Verringern einer Zunahme verringert, die verwendet ist, um die Menge von Kraftstoff, die in die Brennkraftmaschine (2) eingespritzt ist, basierend auf der Differenz zwischen dem Signal, das von dem Sauerstoffsensor (12) ausgegeben ist, und dem Referenzwert zu korrigieren, der dem stöchiometrischen Luftkraftstoffverhältnis entspricht.

6. Luftkraftstoffverhältnissteuergerät für die Brennkraftmaschine (2) nach Anspruch 1 oder 2, ferner mit:

einem Luftkraftstoffverhältnissensor (12), der ein Signal gemäß dem Luftkraftstoffverhältnis des Abgases ausgibt, das in den Katalysator (6) strömt; und
 einem Sauerstoffsensor (12), der ein Signal gemäß einer Konzentration von Sauerstoff in dem Abgas ausgibt, das durch den Katalysator (6) getreten ist,
 wobei die Kraftstoffeinspritzmengensteuereinrichtung (10) die Menge von Kraftstoff, die in die Brennkraftmaschine (2) eingespritzt ist, durch ein Ausführen einer Regelung auf das Luftkraftstoffverhältnis basierend auf einer Differenz zwischen dem Signal, das von dem Luftkraftstoffverhältnissensor (12) ausgegeben ist, und einem Referenzwert steuert, der dem stöchiometrischen Luftkraftstoffverhältnis entspricht, während die Kraftstoffeinspritzmengensteuereinrichtung (10) die Menge von Kraftstoff, die in die Brennkraftmaschine (2) eingespritzt ist, basierend auf einer Differenz zwischen dem Ausgabesignal von dem Sauerstoffsensor (12) und dem Referenzwert korrigiert, der dem stöchiometrischen Luftkraftstoffverhältnis entspricht, und
 wobei die Amplitudenverringereinrichtung (10) die Amplitude der Oszillation des Luftkraftstoffverhältnisses des Abgases, die um das stöchiometrische Luftkraftstoffverhältnis herum oszilliert, durch ein Begrenzen eines Korrekturbetrags basierend auf der Differenz zwischen dem Signal, das von dem Sauerstoffsensor (12) ausgegeben ist, und dem Referenzwert verringert, der dem stöchiometrischen Luftkraftstoffverhältnis entspricht.

7. Luftkraftstoffverhältnissteuergerät für die Brennkraftmaschine (2) nach einem der Ansprüche 1 bis 6, ferner mit

einer Amplitudenverringereinrichtung (10) zum Stoppen eines Verringerens der Amplitude des Luftkraftstoffverhältnisses des Abgases, die um das stöchiometrische Luftkraftstoffverhältnis herum oszilliert, wenn eine von der Kraftstoffzuführabschaltungssteuerung und einer Kraftstoffeinspritzmengenerhöhungssteuerung ausgeführt ist.

8. Luftkraftstoffverhältnissteuergerät für die Brennkraftmaschine (2) nach Anspruch 7, ferner mit einer Ausführungsfrequenzerhöhungseinrichtung (10) zum Erhöhen von wenigstens einer von einer Ausführungsfrequenz der Kraftstoffzuführabschaltungssteuerung und einer Ausführungsfrequenz der Kraftstoffeinspritzmengenerhöhungssteuerung, wenn die Amplitude des Luftkraftstoffverhältnisses des Abgases, die um das stöchiometrische Luftkraftstoffverhältnis herum oszilliert, länger als eine vorgeschriebene Zeitdauer verringert bleibt.
9. Luftkraftstoffverhältnissteuergerät für die Brennkraftmaschine (2) nach Anspruch 7, ferner mit einer Ausführungsfrequenzerhöhungseinrichtung (10) zum Erhöhen von wenigstens einer von einer Ausführungsfrequenz der Kraftstoffzuführabschaltungssteuerung und einer Ausführungsfrequenz der Kraftstoffeinspritzmengenerhöhungssteuerung, wenn eine akkumulierte Menge von Luft, die in die Brennkraftmaschine (2) aufgenommen ist, eine vorgeschriebene Menge übersteigt, nachdem die Amplitude des Luftkraftstoffverhältnisses des Abgases, die um das stöchiometrische Luftkraftstoffverhältnis herum oszilliert, verringert ist.

Revendications

1. Appareil de commande de rapport air-carburant pour un moteur à combustion interne (2) qui comporte un catalyseur (6), disposé dans un passage d'échappement, qui présente une capacité de stockage d'oxygène, **caractérisé par** le fait de comprendre :

un moyen de commande de quantité d'injection de carburant destiné à commander une quantité de carburant injecté au moteur à combustion interne (2) de sorte qu'un rapport air-carburant des gaz d'échappement circulant dans le catalyseur (6) oscille autour d'un rapport air-carburant stoechiométrique ;
 un moyen (10) d'estimation de capacité de stockage d'oxygène estimant un niveau de la capacité de stockage d'oxygène du catalyseur (6),
 un moyen de réduction d'amplitude destiné à réduire une amplitude du rapport air-carburant des gaz d'échappement qui oscille autour du

- rapport air-carburant stoechiométrique lorsqu'on estime que le niveau de la capacité de stockage d'oxygène du catalyseur (6) est inférieur à une capacité de référence prédéterminée,
- un capteur (12) du rapport air-carburant qui délivre en sortie un signal en fonction du rapport air-carburant des gaz d'échappement circulant dans le catalyseur (6),
- où le moyen (10) d'estimation de capacité de stockage d'oxygène estime que le niveau de la capacité de stockage d'oxygène du catalyseur (6) est inférieur à la capacité de référence prédéterminée lorsque l'amplitude du signal délivré en sortie à partir du capteur (12) du rapport air-carburant reste inférieure à une valeur prédéterminée plus longtemps qu'une période prescrite.
2. Appareil de commande de rapport air-carburant pour le moteur à combustion interne (2) selon la revendication 1, comprenant en outre
 - un capteur d'oxygène (14) qui délivre en sortie un signal en fonction d'une concentration d'oxygène dans les gaz d'échappement qui sont passés à travers le catalyseur (6),
 - où le moyen (10) d'estimation de capacité de stockage d'oxygène estime que le niveau de la capacité de stockage d'oxygène est inférieur à la capacité de référence prédéterminée lorsque l'amplitude du signal délivré en sortie à partir du capteur d'oxygène (14) est inférieure à une valeur prédéterminée.
 3. Appareil de commande de rapport air-carburant pour le moteur à combustion interne (2) selon la revendication 1 ou 2, comprenant en outre
 - un capteur (12) du rapport air-carburant qui délivre en sortie un signal en fonction du rapport air-carburant des gaz d'échappement circulant dans le catalyseur (6),
 - où le moyen (10) de commande de quantité d'injection de carburant commande la quantité de carburant injecté au moteur à combustion interne (2) en exécutant une commande de rétroaction sur le rapport air-carburant sur la base d'une différence entre le signal délivré en sortie à partir du capteur (12) du rapport air-carburant et une valeur de référence correspondant au rapport air-carburant stoechiométrique, et
 - où le moyen (10) de réduction d'amplitude réduit l'amplitude du rapport air-carburant des gaz d'échappement qui oscille autour du rapport air-carburant stoechiométrique sur la commande de rétroaction en réduisant un gain utilisé pour corriger la quantité de carburant injecté au moteur à combustion interne (2) sur la base de la différence entre le signal délivré en sortie à partir du capteur (12) du rapport air-carburant et la valeur de référence cor-
- respondant au rapport air-carburant stoechiométrique.
4. Appareil de commande de rapport air-carburant pour le moteur à combustion interne (2) selon la revendication 1 ou 2, comprenant en outre
 - un capteur (12) du rapport air-carburant qui délivre en sortie un signal en fonction du rapport air-carburant des gaz d'échappement circulant dans le catalyseur (6),
 - où le moyen (10) de commande de quantité d'injection de carburant commande la quantité de carburant injecté au moteur à combustion interne (2) en exécutant une commande de rétroaction sur le rapport air-carburant sur la base d'une différence entre le signal délivré en sortie à partir du capteur (12) du rapport air-carburant et une valeur de référence correspondant au rapport air-carburant stoechiométrique, et
 - où le moyen (10) de réduction d'amplitude réduit l'amplitude du rapport air-carburant des gaz d'échappement qui oscille autour du rapport air-carburant stoechiométrique sur la commande de rétroaction en limitant une grandeur de correction sur la base de la différence entre le signal délivré en sortie à partir du capteur (12) du rapport air-carburant et la valeur de référence correspondant au rapport air-carburant stoechiométrique.
 5. Appareil de commande de rapport air-carburant pour le moteur à combustion interne (2) selon la revendication 1 ou 2, comprenant en outre :
 - un capteur (12) du rapport air-carburant qui délivre en sortie un signal en fonction du rapport air-carburant des gaz d'échappement circulant dans le catalyseur (6) ; et
 - un capteur d'oxygène (14) qui délivre en sortie un signal en fonction d'une concentration d'oxygène dans les gaz d'échappement qui sont passés à travers le catalyseur (6),
 - où le moyen (10) de commande de quantité d'injection de carburant commande la quantité de carburant injecté au moteur à combustion interne (2) en exécutant une commande de rétroaction sur le rapport air-carburant sur la base d'une différence entre le signal délivré en sortie à partir du capteur (12) du rapport air-carburant et une valeur de référence correspondant au rapport air-carburant stoechiométrique tandis que le moyen (10) de commande de quantité d'injection de carburant corrige la quantité de carburant injecté au moteur à combustion interne (2) sur la base d'une différence entre le signal de sortie du capteur d'oxygène (12) et la valeur de référence correspondant au rapport air-carburant stoechiométrique, et
 - où le moyen (10) de réduction d'amplitude réduit

- l'amplitude de l'oscillation du rapport air-carburant des gaz d'échappement qui oscille autour du rapport air-carburant stoechiométrique en réduisant un gain utilisé pour corriger la quantité de carburant injecté au moteur à combustion interne (2) sur la base de la différence entre le signal délivré en sortie à partir du capteur d'oxygène (12) et la valeur de référence correspondant au rapport air-carburant stoechiométrique.
6. Appareil de commande de rapport air-carburant pour le moteur à combustion interne (2) selon la revendication 1 ou 2, comprenant en outre un capteur (12) du rapport air-carburant qui délivre en sortie un signal en fonction du rapport air-carburant des gaz d'échappement circulant dans le catalyseur (6) ; et un capteur d'oxygène (12) qui délivre en sortie un signal en fonction d'une concentration d'oxygène dans les gaz d'échappement qui sont passés à travers le catalyseur (6), où le moyen (10) de commande de quantité d'injection de carburant commande la quantité de carburant injecté au moteur à combustion interne (2) en exécutant une commande de rétroaction sur le rapport air-carburant sur la base d'une différence entre le signal délivré en sortie à partir du capteur (12) du rapport air-carburant et une valeur de référence correspondant au rapport air-carburant stoechiométrique tandis que le moyen (10) de commande de quantité d'injection de carburant corrige la quantité de carburant injecté au moteur à combustion interne (2) sur la base d'une différence entre le signal de sortie du capteur d'oxygène (12) et la valeur de référence correspondant au rapport air-carburant stoechiométrique, et où le moyen (10) de réduction d'amplitude réduit l'amplitude de l'oscillation du rapport air-carburant des gaz d'échappement qui oscille autour du rapport air-carburant stoechiométrique en limitant une grandeur de correction sur la base de la différence entre le signal délivré en sortie à partir du capteur d'oxygène (12) et la valeur de référence correspondant au rapport air-carburant stoechiométrique.
7. Appareil de commande de rapport air-carburant pour le moteur à combustion interne (2) selon l'une quelconque des revendications 1 à 6, comprenant en outre un moyen (10) d'arrêt de réduction d'amplitude destiné à arrêter la réduction de l'amplitude du rapport air-carburant des gaz d'échappement qui oscille autour du rapport air-carburant stoechiométrique lorsque l'une d'une commande de coupure d'alimentation en carburant et d'une commande d'augmentation de quantité d'injection de carburant est exécutée.
8. Appareil de commande de rapport air-carburant pour le moteur à combustion interne (2) selon la revendication 7, comprenant en outre un moyen (10) d'augmentation de fréquence d'exécution destiné à augmenter au moins l'une d'une fréquence d'exécution de la commande de coupure d'alimentation en carburant et d'une fréquence d'exécution de la commande d'augmentation de quantité d'injection de carburant lorsque l'amplitude du rapport air-carburant des gaz d'échappement qui oscille autour du rapport air-carburant reste réduite plus longtemps qu'une période prescrite.
9. Appareil de commande de rapport air-carburant pour le moteur à combustion interne (2) selon la revendication 7, comprenant en outre un moyen (10) d'augmentation de fréquence d'exécution destiné à augmenter au moins l'une d'une fréquence d'exécution de la commande de coupure d'alimentation en carburant et d'une fréquence d'exécution de la commande d'augmentation de quantité d'injection de carburant lorsqu'une quantité accumulée d'air introduit dans le moteur à combustion interne (2) dépasse une quantité prescrite après la réduction de l'amplitude du rapport air-carburant des gaz d'échappement qui oscille autour du rapport air-carburant stoechiométrique.

FIG. 1

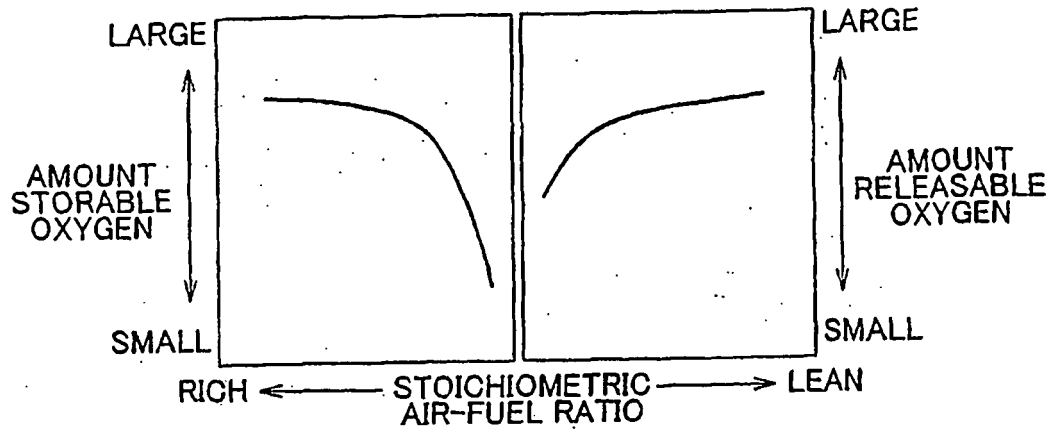


FIG. 2

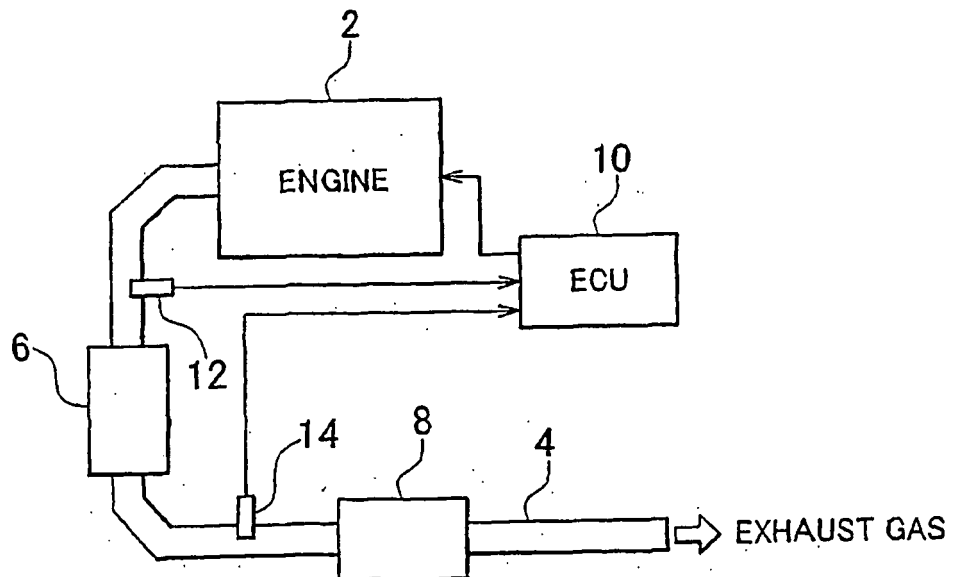
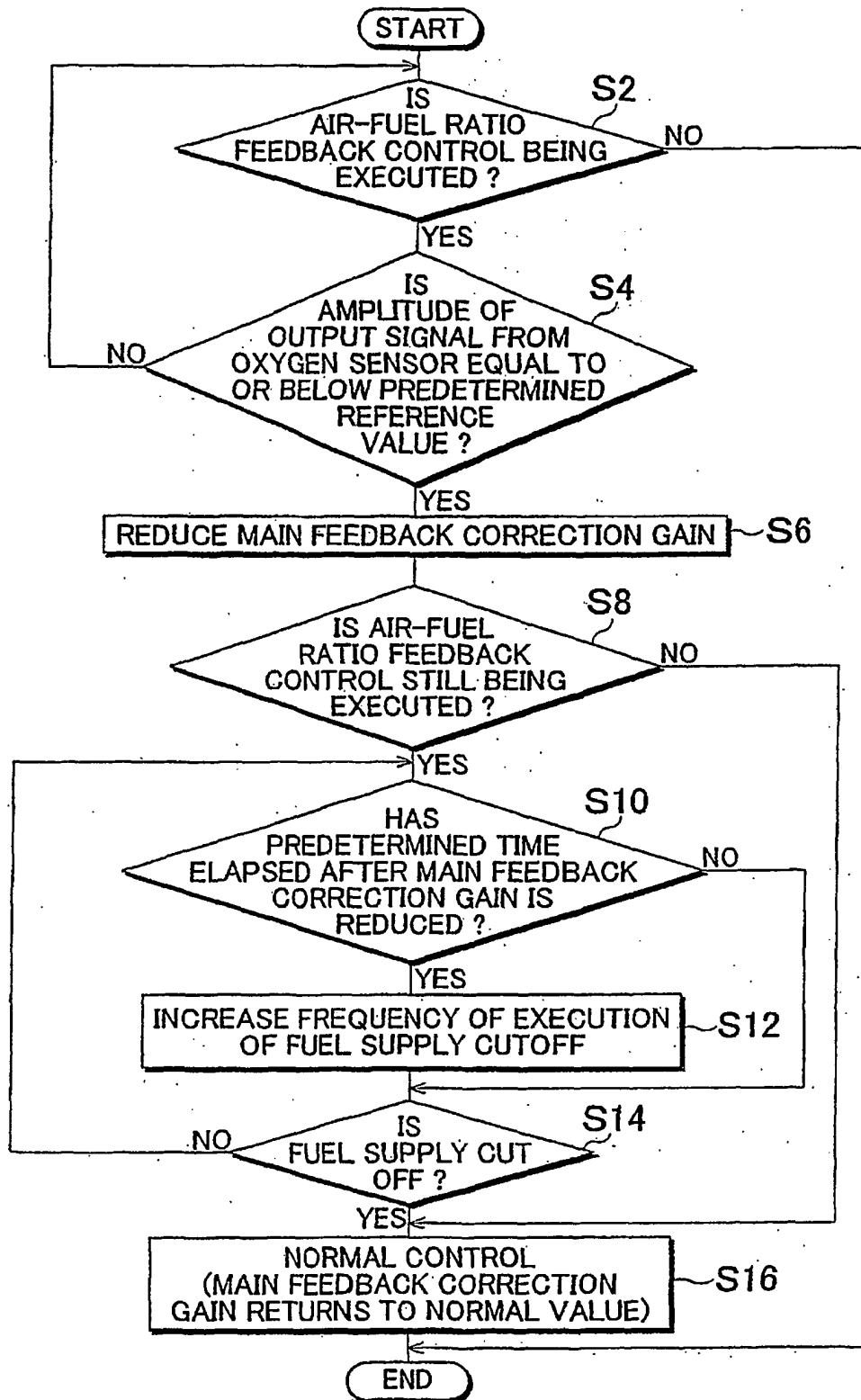


FIG. 3



REFERENCES CITED IN THE DESCRIPTION

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