There is provided an exhaust gas reflux amount adjusting device capable of reducing the possibility of deterioration of a catalyst causing an operation failure of an EGR valve. An EGR gas reflux amount restricting device 30 includes a catalyst deterioration degree calculating unit 31 for calculating a catalyst deterioration degree actual measurement Ddm based on detection results from an air fuel ratio sensor 21 and an oxygen sensor 22, a catalyst deterioration degree determining unit 32 for determining whether the catalyst deterioration degree actual measurement Ddm is equal to or greater than a first predetermined value, and an EGR gas reflux amount restriction instructing unit 33 for controlling an EGR valve 17 to restrict an EGR gas reflux amount when the catalyst deterioration degree determining unit 32 determines that the catalyst deterioration degree actual measurement Ddm is equal to or greater than the first predetermined value.
FIG. 1
FIG. 4

START

CALCULATE CATALYST DETERIORATION DEGREE
ACTUAL MEASUREMENT $D_{dm}$

S12

$D_{dm} \leq 0.43$? NO

YES S13

RESTRICT EGR GAS
REFLUX AMOUNT

DO NOT RESTRICT
EGR GAS REFUX AMOUNT

END

FIG. 5

30A

EGR GAS REFUX AMOUNT
RESTRICTING DEVICE

21

AIR FUEL RATIO SENSOR

22

OXYGEN SENSOR

17

EGR VALVE

31

CATALYST DETERIORATION DEGREE
CALCULATION UNIT

32A

CATALYST DETERIORATION DEGREE
DETERMINING UNIT

33A

EGR GAS REFUX AMOUNT
RESTRICTION INSTRUCTING UNIT
**FIG. 6**

![Graph showing the relationship between catalyst deterioration degree (D_{dm}, D_{da}) and reflux rate.](image)

**FIG. 7**

```
START

CALCULATE CATALYST DETERIORATION DEGREE
ACTUAL MEASUREMENT D_{dm} S21

D_{dm} \geq 0.15? S22

YES S23

RESTRICT EGR GAS
REFUX AMOUNT

NO S24

DO NOT RESTRICT
EGR GAS REFUX AMOUNT

END
```
FIG. 8

AIR FUEL RATIO SENSOR
OXYGEN SENSOR
IGNITION SWITCH
EGR VALVE

EGR GAS REFLUX AMOUNT RESTRICTING DEVICE
IGNITION SWITCH DETERMINING UNIT
POST STARTUP TIME DETERMINING UNIT
CATALYST DETERIORATION DEGREE CALCULATING/RECORDING UNIT
CATALYST DETERIORATION DEGREE AVERAGE CALCULATING UNIT
CONTINUOUS RESTRICTION MODE DETERMINING UNIT
RESTRICTION CANCEL DETERMINING UNIT
RESTRICTION START DETERMINING UNIT
CONTINUOUS RESTRICTION MODE RECORDING UNIT
EGR GAS REFLUX AMOUNT RESTRICTION INSTRUCTING UNIT
FIG. 9

Graph showing the catalyst deterioration degree (Odm. Dda) over the driving cycle.

- First predetermined value
- Second predetermined value

Lines A and B indicate the performance over different cycles.
Fig. 10

START

IS IGNITION SWITCH ON? NO S31

HAS A PREDETERMINED TIME ELAPSED? YES S32

CALCULATE AND RECORD CATALYST DETERIORATION DEGREE ACTUAL MEASUREMENT Ddm S33

CALCULATE CATALYST DETERIORATION DEGREE AVERAGE Dda S34

DOES RESTRICTION MODE CONTINUE? NO S35

YES S36

Dda < 0.15? YES S37

Dda ≥ 0.43? NO

RESTRICT EGR GAS REFLUX AMOUNT S38

RECORD CONTINUOUS RESTRICTION MODE S40

END

DO NOT RESTRICT EGR GAS REFLUX AMOUNT S39
EXHAUST GAS REFLUX AMOUNT ADJUSTING DEVICE

TECHNICAL FIELD

[0001] The present invention relates to an exhaust gas reflux amount adjusting device of an exhaust gas reflux apparatus for channeling back to an inlet pipe a part of exhaust gas from an internal combustion engine as EGR gas.

BACKGROUND ART

[0002] Exhaust gas reflux apparatus (external EGR system) for channeling back to an inlet pipe a part of exhaust gas flowing through an exhaust pipe as EGR gas where the exhaust pipe is connected to the downstream pipe by an EGR gas passage is known, as one of the means for improving internal combustion engine fuel consumption. Demand from the market for improvement in fuel consumption has been increasing in light of countermeasures against global warming and economical efficiency etc. In response thereto, improvement in fuel consumption is devised by channeling back EGR gas not only at times of low load of an internal combustion engine but also at times of high load thereof.

[0003] Moreover, since the lower the exhaust gas temperature becomes, the more the EGR gas can be channeled back to the inlet pipe, it is necessary to cool the EGR gas sufficiently, so as to increase the EGR gas amount at the time of high load. The exhaust gas temperature on the downstream side (rear side) of a catalyst deployed in an exhaust pipe is lower than that on the upstream side (front side) of the catalyst. Therefore, it has been considered that channeling back a part of the exhaust gas on the downstream side of the catalyst as EGR gas is more effective than channeling back a part of the exhaust gas on the upstream side of the catalyst as EGR gas in the conventional manner for channeling back the EGR gas at the time of high load with the internal combustion engine.

[0004] Furthermore, if a part of the exhaust gas on the upstream side of the catalyst is channeled back as EGR gas in the conventional manner, the EGR gas with sediment (deposition in exhaust gas generated due to incomplete fuel combustion in the internal combustion engine will be channeled back to the inlet pipe. In this case, accumulated sediment in an EGR cooler and/or an EGR valve deployed in an EGR gas passage may cause an operation failure. On the other hand, when a part of the exhaust gas on the downstream side of the catalyst is channeled back as EGR gas, the sediment in the exhaust gas will be collected by the catalyst, thereby channeling back the EGR gas with a small amount of sediment to the inlet pipe. As a result, a possibility of sediment in the EGR cooler and/or the EGR valve causing an operation failure decreases.

PRIOR ART DOCUMENT

Patent Document


SUMMARY OF THE INVENTION

Problem to be Solved

[0006] However, not only does deterioration in the catalyst decrease sediment collecting efficiency with the catalyst, but a catalyst washcoat may peel off from the base material of the catalyst. This may cause the catalyst washcoat to bite the EGR valve, leading to an operation failure of the EGR valve when a part of the exhaust gas on the downstream side of the catalyst is channeled back as EGR gas to the inlet pipe. In the worst case, it ends in destruction of the internal combustion engine.

[0007] The present invention is made in order to solve the above mentioned problem, and it aims to provide an exhaust gas reflux amount adjusting device for reducing the possibility of causing an operation failure of the EGR valve due to deterioration of the catalyst, in an exhaust gas reflux apparatus for channeling back a part of the exhaust gas from the downstream side of the catalyst as EGR gas.

Solution to the Problem

[0008] In order to attain this object, according to an aspect of the present invention, an exhaust gas reflux amount adjusting device for an exhaust gas reflux apparatus for channeling back to an inlet pipe a part of exhaust gas from an internal combustion engine is characterized in that the exhaust gas reflux amount adjusting device includes: a catalyst that is deployed in an exhaust pipe and purifies the exhaust gas, an EGR gas passage for connecting the downstream side of the catalyst deployed in the exhaust pipe to the inlet pipe, an EGR valve that is deployed in the EGR gas passage and adjusts the EGR gas reflux amount to be channeled back to the inlet pipe, an upstream oxygen sensor that is deployed on the upstream side of the catalyst deployed in the exhaust pipe and detects an amount of oxygen in the exhaust gas, a downstream oxygen sensor that is deployed on the downstream side of the catalyst deployed in the exhaust pipe and detects the amount of oxygen in the exhaust gas, and an EGR gas reflux amount restricting device for controlling the EGR valve. The EGR gas reflux amount restricting device includes: a catalyst deterioration degree calculating unit for calculating a catalyst deterioration degree based on detection results from the upstream oxygen sensor and the downstream oxygen sensor, and an EGR gas reflux amount restriction instructing unit for instructing the EGR valve to restrict the EGR gas reflux amount. When the catalyst deterioration degree is equal to or greater than a first predetermined value, the EGR gas reflux amount restriction instructing unit controls the EGR valve to restrict the EGR gas reflux amount.

[0009] Moreover, according to an aspect of the present invention, an exhaust gas reflux amount adjusting device for an exhaust gas reflux apparatus for channeling back to an inlet pipe a part of exhaust gas from an internal combustion engine is characterized in that the exhaust gas reflux amount adjusting device includes: a catalyst that is deployed in an exhaust pipe and purifies the exhaust gas, an EGR gas passage for connecting the downstream side of the catalyst deployed in the exhaust pipe to the inlet pipe, an EGR valve that is deployed in the EGR gas passage and adjusts the EGR gas reflux amount to be channeled back to the inlet pipe, an upstream oxygen sensor that is deployed on the upstream side of the catalyst deployed in the exhaust pipe and detects an amount of oxygen in the exhaust gas, a downstream oxygen sensor that is deployed on the downstream side of the catalyst deployed in the exhaust pipe and detects an amount of oxygen in the exhaust gas, and an EGR gas reflux amount restricting device for controlling the EGR valve. The EGR gas reflux amount restricting device includes: a catalyst deterioration degree calculating unit for calculating a catalyst deterioration degree based on detection results from the upstream oxygen sensor and the downstream oxygen sensor, and an EGR gas
reflux amount restriction instructing unit for instructing the EGR valve to restrict the EGR gas reflux amount. When the catalyst deterioration degree is equal to or greater than a second predetermined value, the EGR gas reflux amount restriction instructing unit controls the EGR valve to restrict the EGR gas reflux amount, so that the higher the catalyst deterioration degree is, the smaller is the set reflux rate.

Moreover, according to an aspect of the present invention, an exhaust gas reflux amount adjusting device for an exhaust gas reflux apparatus for channeling back to an inlet pipe a part of exhaust gas from an internal combustion engine is characterized in that the exhaust gas reflux amount adjusting device includes: a catalyst that is deployed in an exhaust pipe and purifies the exhaust gas, an EGR gas passage for connecting the downstream side of the catalyst deployed in the exhaust pipe to the inlet pipe, an EGR valve that is deployed in the EGR gas passage and adjusts the EGR gas reflux amount to be channeled back to the inlet pipe, an upstream oxygen sensor that is deployed on the upstream side of the catalyst deployed in the exhaust pipe and detects an amount of oxygen in the exhaust gas, a downstream oxygen sensor that is deployed on the downstream side of the catalyst deployed in the exhaust pipe and detects an amount of oxygen in the exhaust gas, an EGR gas reflux amount restricting device for controlling the EGR valve. The EGR gas reflux amount adjusting device includes: a catalyst deterioration degree calculating/recording unit for calculating and recording a catalyst deterioration degree actual measurement based on detection results from the upstream oxygen sensor and the downstream oxygen sensor, and an EGR gas reflux amount restriction instructing unit for instructing the EGR valve to restrict the EGR gas reflux amount. The EGR gas reflux amount restricting device records the catalyst deterioration degree actual measurement for every driving cycle and calculates an average of the catalyst deterioration degree actual measurement in every previous driving cycle and catalyst deterioration degree measurement in the present driving cycle, and starts restriction of the EGR gas reflux amount if the average is equal to or greater than a first predetermined value, and cancels the restriction of the EGR gas reflux amount if the average is less than a second predetermined value.

Moreover, an aspect of the present invention is characterized in the restriction of the EGR gas reflux amount is performed by closing the EGR valve.

Moreover, an aspect of the present invention is characterized in that the restriction of the EGR gas reflux amount is that the higher the average or catalyst deterioration degree actual measurement in the present driving cycle, the smaller the set reflux rate.

Advantageous Effect of the Invention

According to an exhaust gas reflux amount adjusting device of the present invention, since sediment not being collected due to deterioration of the catalyst and/or a catalyst member flowed out from the catalyst can be prevented from flowing into an EGR valve, the possibility of causing an operation failure of the EGR valve is reduced.

DESCRIPTION OF EMBODIMENTS

First Embodiment

An exhaust gas reflux amount adjusting device according to an embodiment of the present invention will now be explained referring FIG. 1. An inlet pipe 11 and an exhaust pipe 12 are connected to a cylinder 10 of an internal combustion engine. A catalyst 13 and a muffler 14 are attached to the exhaust pipe 12. The catalyst 13 purifies exhaust gas. An EGR gas passage 15 is deployed, so as to connect the downstream side of the catalyst 13 of the exhaust pipe 12 to the inlet pipe 11. The EGR gas passage 15 channels back exhaust gas to the inlet pipe 11. An EGR cooler 16 is formed in the EGR gas passage 15. An EGR valve 17 is provided in the EGR gas passage 15. The EGR valve 17 adjusts the EGR gas reflux amount, which will be channeled back to the inlet pipe 11. An air fuel ratio sensor (A/F sensor) 21 is formed on the upstream side of the catalyst 13 of the exhaust pipe 12. An oxygen sensor (O2 sensor) 22 is formed on the downstream side of the catalyst 13 of the exhaust pipe 12. An EGR gas reflux amount restricting device 30 is deployed so as to control the EGR valve 17. The EGR gas reflux amount restricting device 30 is constituted by a computer. The exhaust gas reflux amount adjusting device includes the air fuel ratio sensor 21, the oxygen sensor 22, and the EGR gas reflux amount restricting device 30.

The EGR gas reflux amount restricting device 30 shown in FIG. 1 will be explained referring FIG. 2. The EGR gas reflux amount restricting device 30 includes a catalyst deterioration degree calculation unit 31, a catalyst deterioration degree determining unit 32, and an EGR gas reflux amount restriction instructing unit 33.

The catalyst deterioration degree calculation unit 31 calculates a catalyst deterioration degree actual measurement...
The catalyst deterioration degree actual measurement Ddm will be explained referring FIGS. 3A and 3B. FIG. 3A shows a temporal change in an output value from the air fuel ratio sensor 21 while FIG. 3B shows a temporal change in an output value of the oxygen sensor 22. Moreover, a curve A of FIG. 3B shows a temporal change in the output value from the oxygen sensor 22 when the catalyst 13 is normal, and a curve B shows a temporal change in the output value from the oxygen sensor 22 when the catalyst 13 deteriorates. Moreover, when the concentration of the fuel in the exhaust gas is high (rich case), each of the output values from the air fuel ratio sensor 21 and the oxygen sensor 22 approaches “1”. Otherwise, when the concentration of the fuel in the exhaust gas is low (lean case), each of the output values from the air fuel ratio sensor 21 and the oxygen sensor 22 approaches “0”. As is apparent from FIGS. 3A and 3B, the more the catalyst 13 deteriorates, the shorter the change cycle and the amplitude of the output value from the oxygen sensor 22 becomes. This is because when the catalyst 13 deteriorates, oxygen storage capacity for the catalyst 13 declines, and change in oxygen concentration on the downstream side of the catalyst 13 approaches change in oxygen concentration on the upstream side of the catalyst 13. That is, when deterioration of the catalyst 13 progresses, the change cycle T2 of the output value from the oxygen sensor 22 shown in FIG. 3B approaches the change cycle T1 of the output value from the air fuel ratio sensor 21 shown in FIG. 3A, and the catalyst deterioration degree actual measurement Ddm (T1/T2) approaches a value of 1. Therefore, the degree of deterioration in the catalyst 13 can be determined through calculating the catalyst deterioration degree actual measurement Ddm.

The catalyst deterioration degree determining unit 32 determines whether the catalyst deterioration degree actual measurement Ddm is 0.43 (first predetermined value) or greater after the catalyst deterioration degree calculation unit 31 has calculated the catalyst deterioration degree actual measurement Ddm.

The EGR gas reflux amount restriction instructing unit 33 restricts the EGR gas reflux amount through controlling the EGR valve 17 when the catalyst deterioration degree determining unit 32 determines that the catalyst deterioration degree actual measurement Ddm is equal to or greater than 0.43. In this case, the EGR gas reflux amount restriction unit 33 closes the EGR valve 17. Moreover, the EGR gas reflux amount restriction instructing unit 33 does not restrict the EGR gas reflux amount if the catalyst deterioration degree determining unit 32 determines that the catalyst deterioration degree actual measurement Ddm is less than 0.43. That is, the EGR gas reflux amount restriction instructing unit 33 instructs the EGR valve 17 to control the EGR gas reflux amount based on determination by the catalyst deterioration degree determining unit 32.

An operation of the exhaust gas reflux amount adjusting device, which has the EGR gas reflux amount restricting device 30 shown in FIG. 2, will be explained referring FIG. 4. First of all, the catalyst deterioration degree calculation unit 31 calculates the catalyst deterioration degree actual measurement Ddm (Step S11). Next, the catalyst deterioration degree determining unit 32 determines whether the catalyst deterioration degree actual measurement Ddm is equal to or greater than 0.43 (Step S12). If the catalyst deterioration degree determining unit 32 determines that the catalyst deterioration degree actual measurement Ddm is equal to or greater than 0.43, the EGR gas reflux amount restriction instructing unit 33 controls the EGR gas reflux amount (Step S13). Otherwise, if the catalyst deterioration degree determining unit 32 determines that the catalyst deterioration degree actual measurement Ddm is less than 0.43, the EGR gas reflux amount restriction instructing unit 33 does not control the EGR gas reflux amount (Step S14). Note that the exhaust gas reflux amount adjustment is conducted in every driving cycle (DC) from when an ignition switch is turned on so as for the internal combustion engine to start to when the ignition switch is turned off, halting the internal combustion engine. When the EGR gas reflux amount is controlled, the EGR valve 17 is kept to be closed during the driving cycle. Otherwise, when the EGR gas reflux amount is not controlled, the EGR valve 17 is kept to be open during the driving cycle.

In this exhaust gas reflux amount adjusting device, when the catalyst deterioration degree actual measurement Ddm (catalyst deterioration degree) is equal to or greater than 0.43 (first predetermined value), the EGR gas reflux amount restriction instructing unit 33 controls the EGR valve 17 to restrict the EGR gas reflux amount. As a result, sediment not being collected by the catalyst 13 due to deterioration thereof and the catalyst component flown out from the catalyst 13 are prevented from flowing out to the EGR valve catalyst flowing 17, thereby reducing the possibility of leading to an operation failure of the EGR valve 17.

Second Embodiment

An EGR gas reflux amount restricting device 30A in an exhaust gas reflux amount adjusting device according to another embodiment will now be explained referring FIG. 5. This EGR gas reflux amount restricting device 30A has the catalyst deterioration degree calculating unit 31, a catalyst deterioration degree determining unit 32A, and an EGR gas reflux amount restriction instructing unit 33A. Note that the catalyst deterioration degree calculating unit 31 of the EGR gas reflux amount restricting device 30A is the same as the catalyst deterioration degree calculating unit 31 of the EGR gas reflux amount restricting device 30.

The catalyst deterioration degree determining unit 32A determines whether the catalyst deterioration degree actual measurement Ddm is equal to or greater than 0.15 (second predetermined value) after the catalyst deterioration degree calculating unit 31 has calculated the catalyst deterioration degree actual measurement Ddm.

The EGR gas reflux amount restriction instructing unit 33A controls the EGR valve 17 to restrict the EGR gas reflux amount when the catalyst deterioration degree determining unit 32A determines that the catalyst deterioration degree actual measurement Ddm is equal to or greater than 0.15. A relationship between the catalyst deterioration degree actual measurement Ddm (catalyst deterioration degree) in this case and the reflux rate (rate of the restricted EGR gas reflux amount to the EGR gas reflux amount when the catalyst deterioration degree is less than 0.15) is shown in FIG. 6. As the catalyst deterioration degree increases, the reflux rate decreases. That is, the EGR gas reflux amount restriction instructing unit 33A reduces the EGR gas reflux amount when the catalyst deterioration degree is higher. This is because, as the catalyst deterioration degree increases, the exhaust gas reflux amount decreases. As a result, the exhaust gas reflux amount is restricted to prevent sediment from being collected by the catalyst 13 due to deterioration thereof. When the catalyst deterioration degree is less than 0.15, the EGR gas reflux amount is not restricted. Note that the exhaust gas reflux amount adjustment is conducted in every driving cycle (DC) from when an ignition switch is turned on so as for the internal combustion engine to start to when the ignition switch is turned off, halting the internal combustion engine. When the EGR gas reflux amount is restricted, the EGR valve 17 is kept to be closed during the driving cycle. Otherwise, when the EGR gas reflux amount is not restricted, the EGR valve 17 is kept to be open during the driving cycle.
13 is normal) is shown in FIG. 6. Moreover, the EGR gas reflux amount restriction instructing unit 33A does not restrict the EGR gas reflux amount when the catalyst deterioration degree determining unit 32A determines that the catalyst deterioration degree actual measurement Ddm is less than 0.15.

0036 An operation of the exhaust gas reflux amount adjusting device having the EGR gas reflux amount restricting device 30A shown in FIG. 5 will now be explained referring FIG. 7. First of all, the catalyst deterioration degree calculating unit 31 calculates the catalyst deterioration degree actual measurement Ddm (Step S21). Next, the catalyst deterioration degree determining unit 32A determines whether the catalyst deterioration degree actual measurement Ddm is 0.15 or greater (Step S22). If the catalyst deterioration degree determining unit 32A determines that the catalyst deterioration degree actual measurement Ddm is 0.15 or greater, the EGR gas reflux amount restriction instructing unit 33A restricts the EGR gas reflux amount (Step S23). On the other hand, if the catalyst deterioration degree determining unit 32A determines that the catalyst deterioration degree actual measurement Ddm is less than 0.15, the EGR gas reflux amount restriction instructing unit 33A does not restrict the EGR gas reflux amount (Step S24). In these cases, if the catalyst deterioration degree actual measurement Ddm is 0.15 or less, the reflux rate is set to 100%. If the catalyst deterioration degree actual measurement Ddm exceeds 0.15, the higher the catalyst deterioration degree actual measurement Ddm is, the smaller is the reflux rate is set. If the catalyst deterioration degree actual measurement Ddm is 0.43 or greater, the reflux rate is set to 0%. Note that the exhaust gas reflux amount adjustment is performed in every driving cycle. The EGR valve 17 is kept at a predetermined opening during the driving cycle when restricting an EGR gas reflux amount. Otherwise, the EGR valve 17 is kept fully open during the driving cycle when not restricting the EGR gas reflux amount.

0037 In the exhaust gas reflux apparatus for channeling back a part of the exhaust gas from the downstream side of the catalyst 13 as an EGR gas, the higher the catalyst deterioration degree of the catalyst 13, the higher the possibility that the catalyst member flowing out of the catalyst 13 flows to the EGR valve 17. However, in the exhaust gas reflux amount adjusting device, when the catalyst deterioration degree actual measurement Ddm (catalyst deterioration degree) exceeds 0.15 (second predetermined value), the higher the catalyst deterioration degree actual measurement Ddm is, the smaller the reflux rate becomes. As a result, the possibility of causing an operation failure of the EGR valve due to deterioration of the catalyst is appropriately reduced, and fuel consumption may be improved.

Third Embodiment

0038 An EGR as reflux amount restricting device 30B of an exhaust as reflux amount adjusting device according to another embodiment will be described referring FIG. 8. The EGR gas reflux amount restricting device 30B includes an ignition switch determining unit 34, a post startup time determining unit 35, a catalyst deterioration degree calculating/recording unit 36, a catalyst deterioration degree average calculating unit 37, a continuous restriction mode determining unit 38, a restriction cancel determining unit 39, a restriction start determining unit 40, an EGR gas reflux amount restriction instructing unit 33B, and continuous restriction mode recording unit 41.

0039 The ignition switch determining unit 34 determines whether an ignition switch 23 is on.

0040 When the post startup time determining unit 35 has determined that the ignition switch 23 is on, it then determines whether a predetermined time has elapsed after the engine starts.

0041 The catalyst deterioration degree calculating/recording unit 36 calculates the catalyst deterioration degree actual measurement Ddm, and records the catalyst deterioration degree actual measurement Ddm when the post startup time determining unit 35 has determined that a predetermined time has elapsed after the engine has started. Therefore, the catalyst deterioration degree actual measurement Ddm for every driving cycle is recorded.

0042 The catalyst deterioration degree average calculating unit 37 calculates an average of the catalyst deterioration degree actual measurements Ddm recorded so far and the catalyst deterioration degree actual measurement Ddm recorded at this time, namely, the catalyst deterioration degree average Dda once the catalyst deterioration degree calculating/recording unit 36 records the catalyst deterioration degree actual measurement Ddm.

0043 The continuous restriction mode determining unit 38 determines whether the continuous restriction mode recording unit 41 has recorded the “continuous restriction mode” after the catalyst deterioration degree average calculating unit 37 has calculated the catalyst deterioration degree average Dda.

0044 The restriction cancel determining unit 39 determines whether restriction of the EGR gas reflux amount is canceled, that is, whether the catalyst deterioration degree average Dda is less than 0.15 (second predetermined value), when the continuous restriction mode determining unit 38 has determined that the continuous restriction mode recording unit 41 has recorded the “continuous restriction mode”. Note that an example of the catalyst deterioration degree actual measurement Ddm (line A) in every driving cycle and an example of the catalyst deterioration degree average Dda (line B) are shown in FIG. 9.

0045 If the continuous restriction mode determining unit 38 has determined that the continuous restriction mode recording unit 41 has not recorded the “continuous restriction mode”, the restriction start determining unit 40 determines whether restriction of the EGR gas reflux amount should be started, that is, whether the catalyst deterioration degree average Dda is equal to or greater than 0.43 (first predetermined value).

0046 The EGR gas reflux amount restriction instructing unit 33B controls the EGR valve 17 based on determination of the restriction cancel determining unit 39 and the restriction start determining unit 40. That is, when the restriction cancel determining unit 39 determines that the catalyst deterioration degree average Dda is 0.15 or greater, that is, when it determines that restriction of the EGR gas reflux amount is not canceled, and the restriction start determining unit 40 determines that the catalyst deterioration degree average Dda is 0.43 or greater, that is, when it determines that restriction of the EGR gas reflux amount should be started, the EGR gas reflux amount restriction instructing unit 33B controls the EGR valve 17 to restrict the EGR gas reflux amount. Moreover, when the restriction cancel determining unit 39 has determined that restriction of the EGR gas
reflux amount is canceled, and when the restriction start determining unit 40 has determined that the catalyst deterioration degree average Dda is less than 0.43, that is, when restriction of the EGR gas reflux amount should not be started, the EGR gas reflux amount restriction instructing unit 33B does not restrict the EGR gas reflux amount.

The continuous restriction mode recording unit 41 records whether it is in the continuous restriction mode after the EGR gas reflux amount restriction instructing unit 33B has controlled the EGR valve 17. That is, when the restriction cancel determining unit 39 does not cancel restriction of the EGR gas reflux amount, and when the restriction start determining unit 40 has determined that restriction of the EGR gas reflux amount should be started, the continuous restriction mode recording unit 41 records the “continuous restriction mode”. When the restriction cancel determining unit 39 cancels restriction of the EGR gas reflux amount, and when the restriction start determining unit 40 does not start restriction of the EGR gas reflux amount, the continuous restriction mode recording unit 41 does not record the “continuous restriction mode”. When the restriction cancel determining unit 39 cancels restriction of the EGR gas reflux amount, and when the restriction start determining unit 40 does not start restriction of the EGR gas reflux amount, if the “continuous restriction mode” is recorded, it is then eliminated.

An operation of the exhaust gas reflux amount adjusting device having the EGR gas reflux amount restricting device 305 shown in FIG. 8 will now be explained referring FIG. 10. First of all, the ignition switch determining unit 34 determines whether the ignition switch 23 is on (Step S31). If the ignition switch 23 is not on, the ignition switch determining unit 34 determines repeatedly whether the ignition switch 23 is on. If the ignition switch determining unit 34 determines that the ignition switch 23 is on, the post startup time determining unit 35 determines whether a predetermined time has elapsed after the engine started (Step S32). If the post startup time determining unit 35 determines that a predetermined time has elapsed after the engine started, the catalyst deterioration degree calculating/ recording unit 36 calculates the catalyst deterioration degree actual measurement Ddm, and records the catalyst deterioration degree actual measurement Ddm (Step S33). After the catalyst deterioration degree calculating/ recording unit 36 records the catalyst deterioration degree actual measurement Ddm, the catalyst deterioration degree actual measurement calculating unit 37 calculates the catalyst deterioration degree average Dda (Step S34).

After the catalyst deterioration degree average calculating unit 37 calculates the catalyst deterioration degree average Dda, the continuous restriction mode determining unit 38 determines whether the continuous restriction mode recording unit 41 has recorded the “continuous restriction mode” (Step S35). If the continuous restriction mode determining unit 38 determines that the continuous restriction mode recording unit 41 is recording the “continuous restriction mode”, the restriction cancel determining unit 39 determines whether restriction of the EGR gas reflux amount is canceled or not (Step S36). On the other hand, if the continuous restriction mode determining unit 38 determines that the continuous restriction mode recording unit 41 has not recorded the “continuous restriction mode”, the restriction start determining unit 40 determines whether restriction of the EGR gas reflux amount should be started or not (Step S37).

If the restriction cancel determining unit 39 determines that the catalyst deterioration degree average Dda is 0.15 or greater, that is, if it determines that restriction of the EGR gas reflux amount is not canceled, and if the restriction start determining unit 40 determines that the catalyst deterioration degree average Dda is 0.43 or greater, that is, if it determines that restriction of the EGR gas reflux amount should be started, the EGR gas reflux amount restriction instructing unit 33B controls the EGR valve 17 to leave the EGR valve 17 closed until the ignition switch 23 turns off, thereby restricting the EGR gas reflux amount (Step S38). Moreover, if the restriction cancel determining unit 39 determines that the catalyst deterioration degree average Dda is less than 0.15, that is, if it confirms that restriction of the EGR gas reflux amount is canceled, and if the restriction start determining unit 40 determines that the catalyst deterioration degree average Dda is less than 0.43, that is, if it determines that restriction of the EGR gas reflux amount should not be started, the EGR gas reflux amount restriction instructing unit 33B leaves the EGR valve 17 open until the ignition switch 23 turns off, thereby not restricting the EGR gas reflux amount (Step S39). After the EGR gas reflux amount restriction instructing unit 33B has controlled the EGR valve 17, the continuous restriction mode recording unit 41 records whether or not it is in the continuous restriction mode (Step S40).

Note that if the catalyst deterioration degree average Dda exceeds 0.15, the greater the catalyst deterioration degree average Dda, the smaller the reflux rate is set, and the reflux rate may be set to 0% if the catalyst deterioration degree average Dda is 0.43 or greater, so as for the EGR gas reflux amount restriction instructing unit 33B to restrict the EGR gas reflux amount.

In this exhaust gas reflux amount adjusting device, if there is a possibility that the catalyst 13 has deteriorated, the EGR gas reflux amount is restricted, thereby reducing the possibility of causing an operation failure of the EGR valve 17. Moreover, when it is determined that the catalyst has not deteriorated, restriction of the EGR gas reflux amount is canceled, thereby improving fuel consumption.

Moreover, if the post startup time determining unit 35 determines that a predetermined time has elapsed after the engine started, the catalyst deterioration degree calculating/ recording unit 36 calculates the catalyst deterioration degree actual measurement Ddm. Therefore, since the catalyst deterioration degree actual measurement Ddm can be calculated after the temperature of the internal combustion engine rises, the catalyst deterioration degree actual measurement Ddm can be calculated accurately.

Other Embodiments

Note that according to the abovementioned embodiment, the first predetermined value is set to 0.43, and the second predetermined value is set to 0.15. Alternatively, the first and the second predetermined value may be set to other values.

Moreover, while in the abovementioned embodiment, the air fuel ratio sensor 21 and the oxygen sensor 22 are used as an upstream oxygen sensor and a downstream oxygen sensor, respectively, an oxygen sensor provided on the upstream side of the catalyst 13 may be used as the upstream oxygen sensor, and an air fuel ratio sensor provided on the downstream side of the catalyst 13 may be used as the downstream oxygen sensor. Moreover, a variety of sensors capable...
of detecting the amount of oxygen in exhaust gas may be used as the upstream oxygen sensor and the downstream oxygen sensor.

[0056] Furthermore, in the first embodiment, when the catalyst deterioration degree determining unit 32 determines that the catalyst deterioration degree actual measurement Ddm is 0.43 (first predetermined value) or greater, the EGR gas reflux amount restriction instructing unit 33 restricts the EGR gas reflux amount. Alternatively, when the catalyst deterioration degree determining unit 32 determines that the catalyst deterioration degree actual measurement Dda is equal to or greater than the first predetermined value, the EGR gas reflux amount may be restricted. That is, in the first embodiment, the catalyst deterioration degree actual measurement Ddm is used as a catalyst deterioration degree. Alternatively, the catalyst deterioration degree actual measurement Dda may be used as the catalyst deterioration degree.

[0057] Further, in the second embodiment, when the catalyst deterioration degree determining unit 32A determines that the catalyst deterioration degree actual measurement Ddm is 0.15 (second predetermined value) or greater, the EGR gas reflux amount restriction instructing unit 33A has restricted the EGR gas reflux amount. Alternatively, the catalyst deterioration degree determining unit 32A determines that the catalyst deterioration degree actual measurement Dda is equal to or greater than the second predetermined value. In this case, the higher the catalyst deterioration degree actual measurement Dda, the smaller the set reflux rate. That is, in the second embodiment, the catalyst deterioration degree actual measurement Ddm is used as the catalyst deterioration degree. Alternatively, the catalyst deterioration degree actual measurement Dda may be used as the catalyst deterioration degree.

[0058] Further, in the third embodiment, if the catalyst deterioration degree actual measurement Dda exceeds 0.15, the higher the catalyst deterioration degree actual measurement Dda, the smaller the set reflux rate, and the reflux rate is set to 0% if the catalyst deterioration degree actual measurement Dda is 0.43 or greater. Alternatively, if the catalyst deterioration degree actual measurement Ddm in this driving cycle exceeds 0.15, the higher the catalyst deterioration degree actual measurement Ddm in the driving cycle, the smaller the set reflux rate. If the catalyst deterioration degree actual measurement Ddm in this driving cycle is 0.43 or greater, the reflux rate may be set to 0%.

[0059] The present invention is not limited to the exemplified and illustrated embodiments, and the present invention includes all embodiments providing the same advantageous effects as the object of the present invention. Furthermore, the present invention is not limited to the combinations of the features claimed in respective claims according to the present Invention, and the present invention may be constituted by any desired combinations of specific features disclosed.

Reference Signs List

[0060] 11: INLET PIPE
[0061] 12: EXHAUST PIPE
[0062] 13: CATALYST
[0063] 15: EGR GAS PASSAGE
[0064] 17: EGR VALVE
[0065] 21: AIR FUEL RATIO SENSOR
[0066] 22: OXYGEN SENSOR
[0067] 31, 30A, 30B: IGNITION SWITCH
[0068] 30, 30A, 30B: EGR GAS REFLUX AMOUNT RESTRICTING DEVICE

[0069] 31: CATALYST DETERIORATION DEGREE CALCULATING UNIT
[0070] 32, 32A: CATALYST DETERIORATION DEGREE DETERMINING UNIT
[0071] 33, 33A, 33B: EGR GAS REFLUX AMOUNT RESTRICTION INSTRUCTING UNIT
[0072] 34: IGNITION SWITCH DETERMINING UNIT
[0073] 35: POST STARTUP TIME DETERMINING UNIT
[0074] 36: CATALYST DETERIORATION DEGREE CALCULATING/RECORDING UNIT
[0075] 37: CATALYST DETERIORATION DEGREE AVERAGE CALCULATING UNIT
[0076] 38: CONTINUOUS RESTRICTION MODE DETERMINING UNIT
[0077] 39: RESTRICTION CANCEL DETERMINING UNIT
[0078] 40: RESTRICTION START DETERMINING UNIT
[0079] 41: CONTINUOUS RESTRICTION MODE RECORDING UNIT

1. An exhaust gas reflux amount adjusting device for an exhaust gas reflux apparatus for channeling back to an inlet pipe a part of exhaust gas from an internal combustion engine, said exhaust gas reflux amount adjusting device comprising:
   a catalyst that is deployed in an exhaust pipe and purifies the exhaust gas;
   an EGR gas passage for connecting the downstream side of the catalyst deployed in the exhaust pipe to the inlet pipe, an EGR valve that is deployed in the EGR gas passage and adjusts the EGR gas reflux amount to be channeled back to the inlet pipe;
   an upstream oxygen sensor that is deployed on the upstream side of the catalyst deployed in the exhaust pipe and detects an amount of oxygen in the exhaust gas;
   a downstream oxygen sensor that is deployed on the downstream side of the catalyst deployed in the exhaust pipe and detects the amount of oxygen in the exhaust gas; and
   an EGR gas reflux amount restricting device for controlling the EGR valve, and
   wherein the EGR gas reflux amount restricting device comprises:
   a catalyst deterioration degree calculating unit for calculating a catalyst deterioration degree based on detection results from the upstream oxygen sensor and the downstream oxygen sensor; and
   an EGR gas reflux amount restriction instructing unit for instructing the EGR valve to restrict the EGR gas reflux amount, and
   wherein when the catalyst deterioration degree is equal to or greater than a first predetermined value, the EGR gas reflux amount restriction instructing unit controls the EGR valve to restrict the EGR gas reflux amount.

2. An exhaust gas reflux amount adjusting device for an exhaust gas reflux apparatus for channeling back to an inlet pipe a part of exhaust gas from an internal combustion engine, said exhaust gas reflux amount adjusting device comprising:
   a catalyst that is deployed in an exhaust pipe and purifies the exhaust gas;
   an EGR gas passage for connecting the downstream side of the catalyst deployed in the exhaust pipe to the inlet pipe, an EGR valve that is deployed in the EGR gas passage and adjusts the EGR gas reflux amount to be channeled back to the inlet pipe;
an upstream oxygen sensor that is deployed on the upstream side of the catalyst deployed in the exhaust pipe and detects an amount of oxygen in the exhaust gas; a downstream oxygen sensor that is deployed on the downstream side of the catalyst deployed in the exhaust pipe and detects an amount of oxygen in the exhaust gas; and an EGR gas reflux amount restricting device for controlling the EGR valve, and wherein the EGR gas reflux amount restricting device comprises:

- a catalyst deterioration degree calculating unit for calculating a catalyst deterioration degree based on detection results from the upstream oxygen sensor and the downstream oxygen sensor; and
- an EGR gas reflux amount restriction instructing unit for instructing the EGR valve to restrict the EGR gas reflux amount, and wherein when the catalyst deterioration degree is equal to or greater than a second predetermined value, the EGR gas reflux amount restriction instructing unit controls the EGR valve to restrict the EGR gas reflux amount so that the higher the catalyst deterioration degree is, the smaller is the set reflux rate.

3. An exhaust gas reflux amount adjusting device for an exhaust gas reflux apparatus for channeling back to an inlet pipe a part of exhaust gas from an internal combustion engine; said exhaust gas reflux amount adjusting device comprising:

- a catalyst that is deployed in an exhaust pipe and purifies the exhaust gas;
- an EGR gas passage for connecting the downstream side of the catalyst deployed in the exhaust pipe to the inlet pipe; an EGR valve that is deployed in the EGR gas passage and adjusts the EGR gas reflux amount to be channeled back to the inlet pipe;
- an upstream oxygen sensor that is deployed on the upstream side of the catalyst deployed in the exhaust pipe and detects an amount of oxygen in the exhaust gas; a downstream oxygen sensor that is deployed on the downstream side of the catalyst deployed in the exhaust pipe and detects an amount of oxygen in the exhaust gas; an EGR gas reflux amount restricting device for controlling the EGR valve, and wherein the EGR gas reflux amount restricting device comprises:

- a catalyst deterioration degree calculating/recording unit for calculating and recording a catalyst deterioration degree actual measurement value based on detection results from the upstream oxygen sensor and the downstream oxygen sensor; and
- an EGR gas reflux amount restriction instructing unit for instructing the EGR valve to restrict the EGR gas reflux amount, and wherein the EGR gas reflux amount restricting device records the catalyst deterioration degree actual measurement value for every driving cycle and calculates an average of the catalyst deterioration degree actual measurement in every previous driving cycle and catalyst deterioration degree measurement in the present driving cycle, and starts restriction of the EGR gas reflux amount if the average is equal to or greater than a first predetermined value, and cancels the restriction of the EGR gas reflux amount if the average is less than a second predetermined value.

4. The exhaust gas reflux amount adjusting device according to claim 3, wherein the restriction of the EGR gas reflux amount is performed by closing the EGR valve.

5. The exhaust gas reflux amount adjusting device according to claim 3, wherein the restriction of the EGR gas reflux amount is performed so that the higher the average or the catalyst deterioration degree actual measurement in the present driving cycle is, the smaller is the set reflux rate.