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(71) Applicant(s)
Ford Global Technologies, Inc.
(Incorporated in USA - Michigan)
600 Parklane Towers East, One Parklane Boulevard, Dearborn, Michigan 48126, United States of America

(72) Inventor(s)
David George Farmer
Gopichandra Surnilla
Jerry Dean Robichaux
Salomone Castro

(74) Agent and/or Address for Service
A. Messulam & Co. Ltd
43-45 High Road, BUSHEY HEATH, Herts, WD2 1EE, United Kingdom

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ONLINE: EPODOC, JAPIO, WPI.

(54) Abstract Title
Air/fuel ratio control system

(57) A nitrous oxide trap temperature control system for desulfating the trap uses and engine with some cylinders operating with lean combustion and some cylinders operating with rich combustion. The lean and rich combustion gases are combined to form an mixture which is fed to the trap to provide an exothermic reaction. The desired lean and rich air/fuel ratios of the respective lean and rich cylinders are determined based in part on the difference between the trap temperature and a desired trap temperature. The desired lean and rich air/fuel ratios of the respective lean and rich cylinders are also determined from the desired mixture air/fuel ratio entering the trap.

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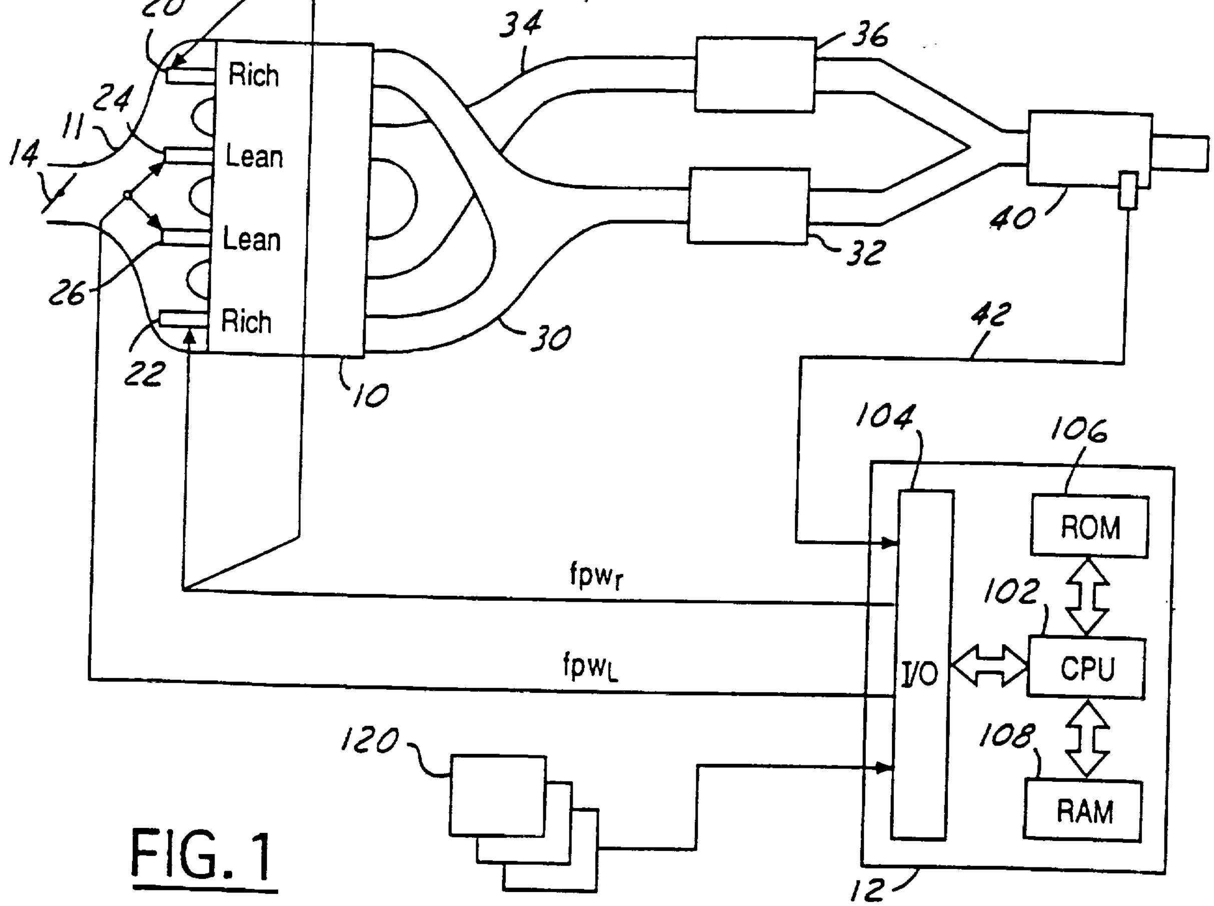

FIG. 1

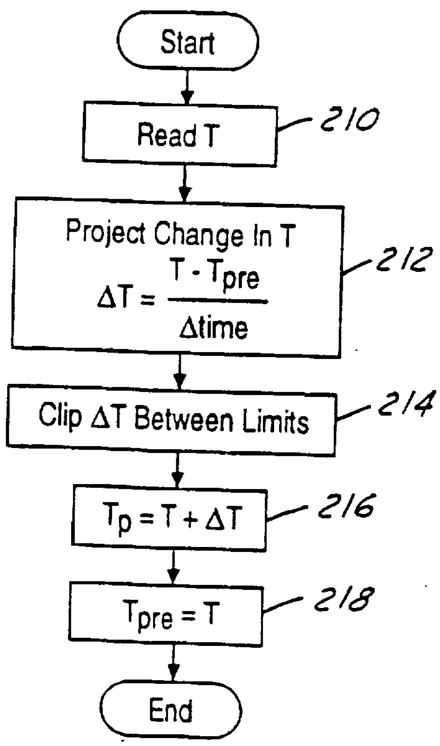

FIG. 2

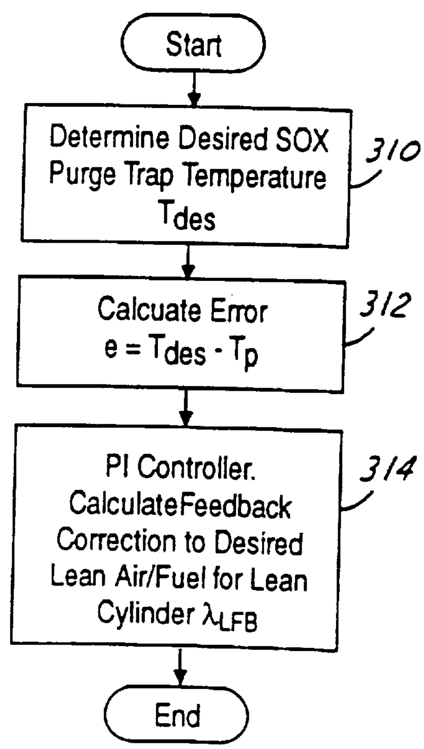

FIG. 3

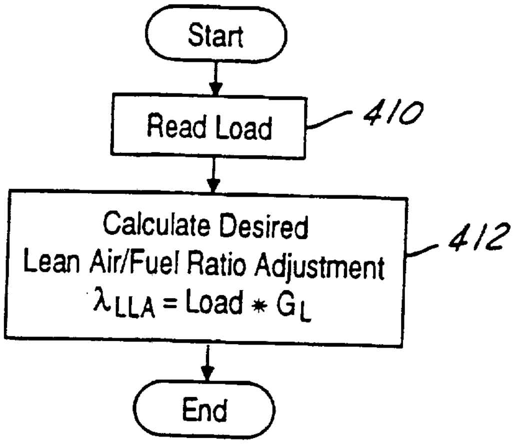

FIG. 4

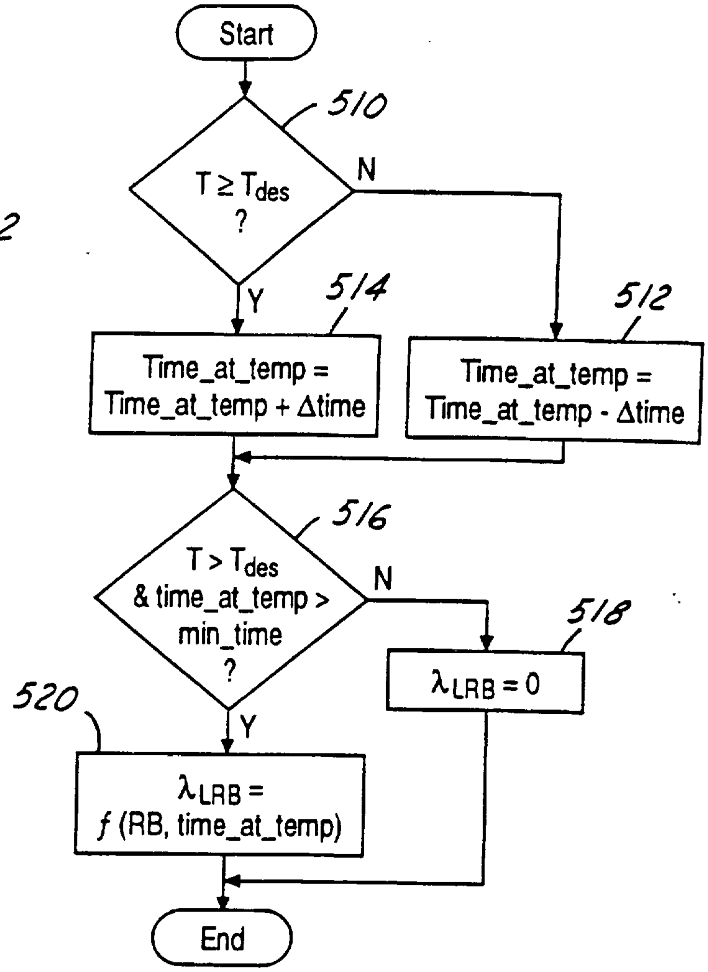

FIG. 5

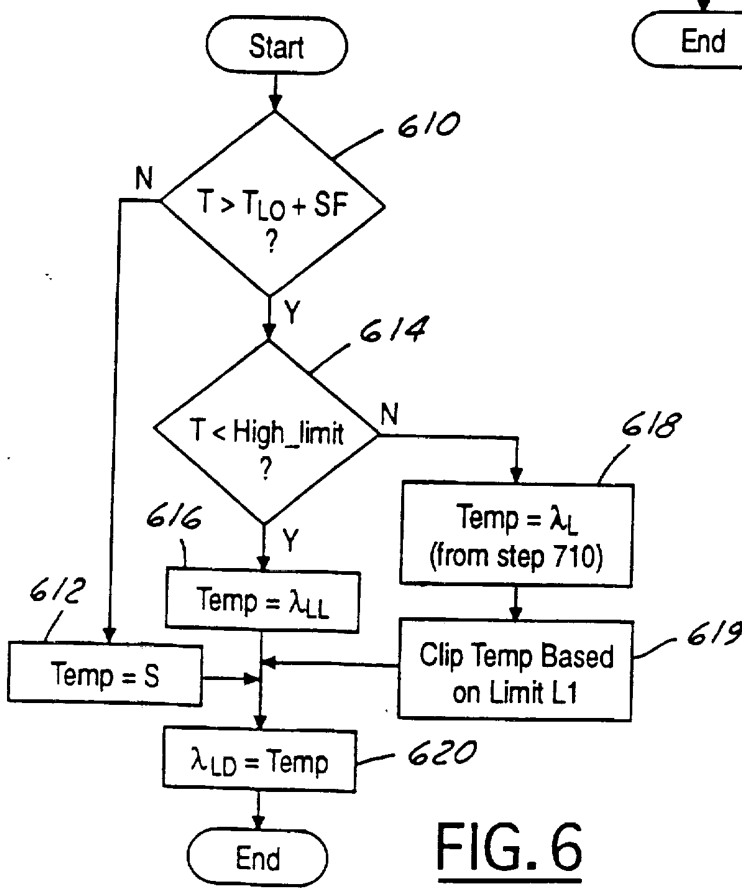

FIG. 6

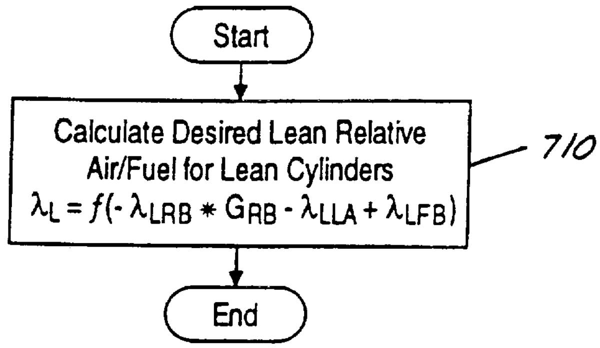
Start
Calculate Desired Lean Relative Air/Fuel for Lean Cylinders
$\lambda_L = f(-\lambda_{LRB} * G_{RB} - \lambda_{LLA} + \lambda_{LFB})$
710
End

FIG. 7

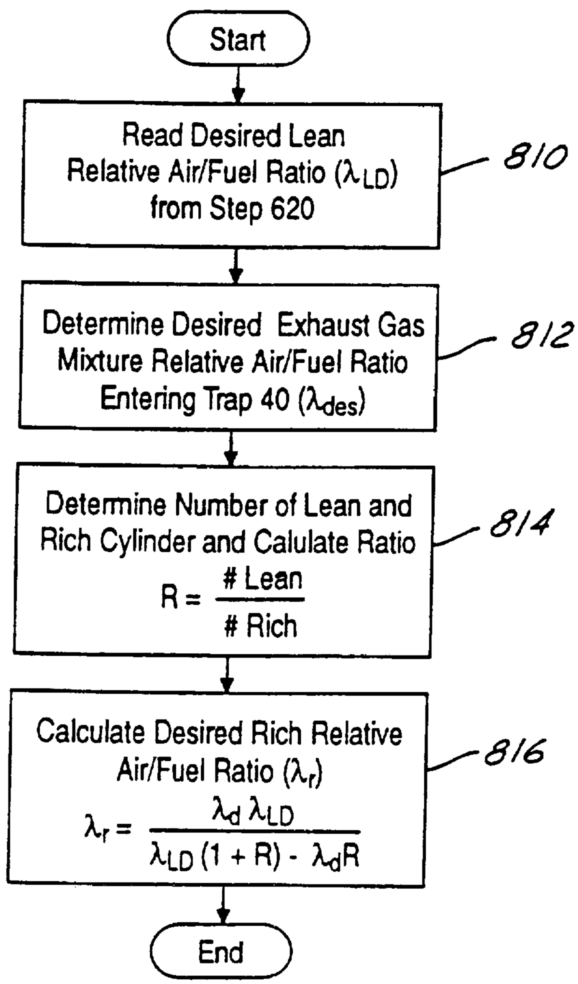
Start
Read Desired Lean Relative Air/Fuel Ratio (λ_{LD}) from Step 620
810
Determine Desired Exhaust Gas Mixture Relative Air/Fuel Ratio Entering Trap 40 (λ_{des})
812
Determine Number of Lean and Rich Cylinder and Calulate Ratio
$R = \frac{\# Lean}{\# Rich}$
814
Calculate Desired Rich Relative Air/Fuel Ratio (λ_r)
$\lambda_r = \frac{\lambda_d \lambda_{LD}}{\lambda_{LD}(1 + R) - \lambda_d R}$
816
End

FIG. 8

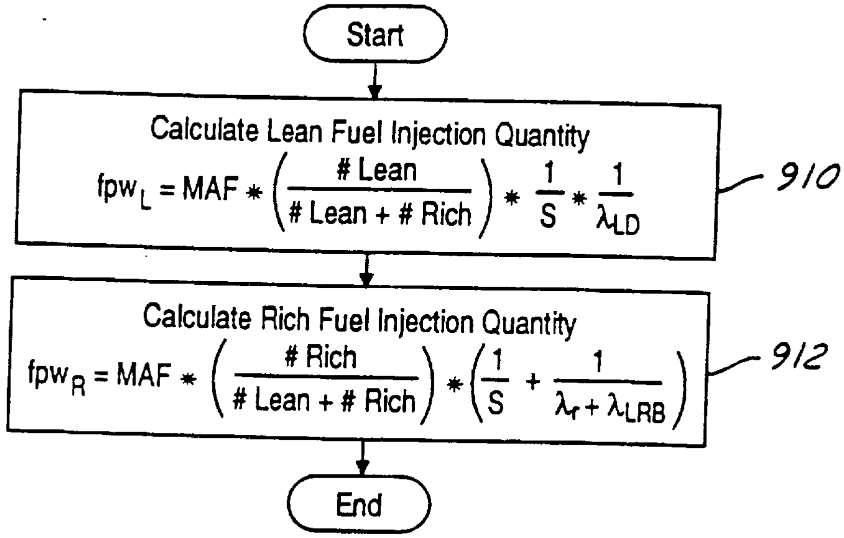
Start
Calculate Lean Fuel Injection Quantity
$fpw_L = MAF * \left(\frac{\# Lean}{\# Lean + \# Rich}\right) * \frac{1}{S} * \frac{1}{\lambda_{LD}}$
910
Calculate Rich Fuel Injection Quantity
$fpw_R = MAF * \left(\frac{\# Rich}{\# Lean + \# Rich}\right) * \left(\frac{1}{S} + \frac{1}{\lambda_r + \lambda_{LRB}}\right)$
912
End

FIG. 9

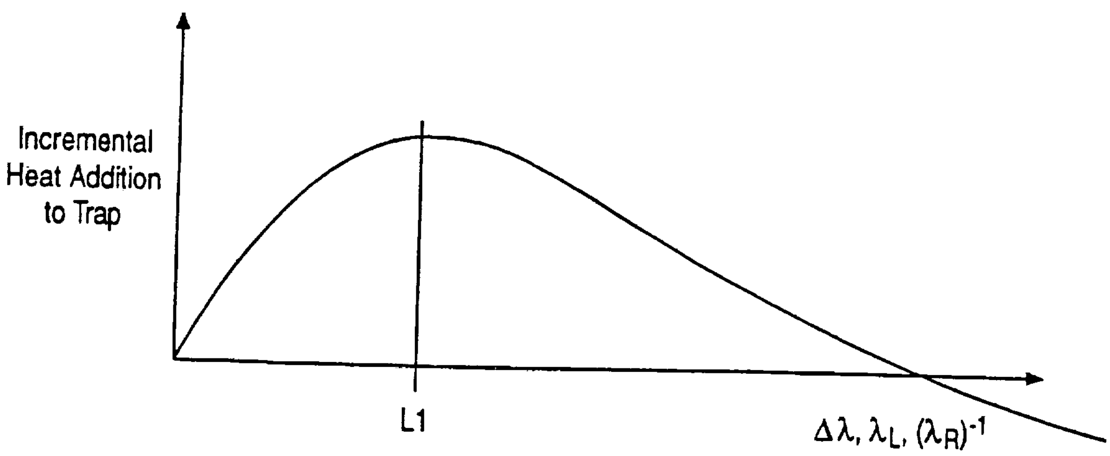
Incremental Heat Addition to Trap
L1
$\Delta\lambda, \lambda_L, (\lambda_R)^{-1}$

FIG. 10

Air/Fuel Ratio Control System

The invention relates to a system and method for controlling the air/fuel ratio of a mixture of exhaust gasses entering an emission control device during sulphur purging.

Engine systems are known which operate the engine with lean combustion, or a lean air/fuel ratio, to improve fuel economy. To accommodate lean burn conditions, emission control devices, such as nitrous oxide (NOx) traps, are used to adsorb nitrous oxide emissions produced during lean operation. Adsorbed nitrous oxide is periodically purged by operating the engine with rich combustion, or a rich air/fuel ratio.

During normal lean and rich operation, sulphur contained in the fuel can become trapped in the emission control device. This gradually degrades the emission device capacity for storing nitrous oxide, as well as the device efficiency. To counteract the sulphur effect, various sulphur decontamination methods are available.

One method for sulphur decontamination requires elevating the emission control device temperature to a predetermined value. Then, additional fuel is injected while the catalyst is at this elevated temperature to reduce the sulphur stored in the device. The temperature of the device is raised by operating some of the cylinders lean and some of the cylinders rich. When the lean and rich exhaust gasses meet in the device, exothermic reactions takes place, thereby releasing heat to increase the device temperature. The lean and rich exhaust gases are kept at certain desired lean and rich air/fuel ratios to maintain the average air/fuel ratio of the mixed exhaust gases at a desired air/fuel ratio. The desired lean and rich air/fuel ratios are determined in table look-up fashion with various correction factors. An exhaust gas air/fuel ratio sensor is relied upon to correct the desired lean and rich air/fuel ratios for control errors in the correction factors. Such a method is described in U.S. 5,657,625.

The inventors herein have recognized a disadvantage with the above approach. In particular, the method described for maintaining the average mixed exhaust air/fuel ratio is cumbersome and overly complex. In addition the above method requires an additional exhaust air/fuel ratio sensor because the open loop methods are not robust. Extensive testing and development, along with excessive computer memory storage and cost are necessary to use the above method. In other words, a simple, straightforward, and accurate method is not shown for determining a desired lean air/fuel ratio for the lean cylinders and a desired rich air/fuel ratio for the rich cylinders such that a desired exhaust gas mixture air/fuel ratio is achieved.

The invention seeks to provide a system and method for controlling cylinder air/fuel ratios for desulfating an emission control device, whereby the emission control device is heated by operating some cylinders of an engine lean and some cylinders of an engine rich.

The above object is achieved, and disadvantages of prior approaches overcome, by a method for air/fuel ratio control of an exhaust gas mixture entering an emission control device, the emission control device located in an exhaust passage of an internal combustion engine having at least a first and second cylinder. The method comprising the steps of generating a desired lean air/fuel ratio for the first cylinder so that a desired emission control device temperature is achieved, operating the first cylinder at said desired lean air/fuel ratio, generating a desired rich air/fuel ratio for the second cylinder based on said desired lean air/fuel ratio and based on a desired air/fuel ratio of the exhaust gas mixture, wherein exhaust gasses from the first and second cylinders form the exhaust gas mixture, and operating the second cylinder at said desired rich air/fuel ratio.

By calculating the desired lean air/fuel ratio for the lean cylinders to control trap temperature and then calculating a corresponding rich air/fuel ratio for the rich cylinders, the exhaust mixture from the lean and rich cylinder can be accurately controlled to form a desired mixture air/fuel ratio. In other words, the temperature control task is used for calculating the desired lean air/fuel ratio, since increasing or decreasing the lean air/fuel ratio has the effect of increasing or decreasing trap temperature. Then, since a certain air/fuel ratio is desired for the mixture of the lean and rich cylinders, this desired mixture air/fuel ratio, along with the just calculated lean air/fuel ratio is used to calculate the desired rich air/fuel ratio. In this way, the temperature is controlled to the desired level and the mixture from the lean and rich cylinders forms a desired mixture air/fuel ratio with no additional correction or sensor feedback feedback.

In an alternative embodiment, he above object is achieved, and disadvantages of prior approaches overcome, by a method for air/fuel ratio control of an exhaust gas mixture entering an emission control device, the emission control device located in an exhaust passage of an internal combustion engine having at least a first and second cylinder, the method comprising the steps of generating a desired rich air/fuel ratio for the first cylinder so that a desired emission control device temperature is achieved, operating the first cylinder at said desired rich air/fuel ratio, generating a desired lean air/fuel ratio for the second cylinder based on said desired rich air/fuel ratio and based on a desired air/fuel ratio of the mixture of exhaust gasses, wherein exhaust gasses from the first and second cylinders form the exhaust gas mixture, and operating the second cylinder at said desired lean air/fuel ratio.

In this embodiment, the calculation order is reversed, and the rich air/fuel ratio is first calculated to control the trap temperature. Then, the lean air/fuel ratio is calculated based on the rich air/fuel ratio and the desired mixture air/fuel ratio. By calculating the desired rich air/fuel ratio for the rich cylinders to control temperature and then calculating a corresponding lean air/fuel ratio for the lean cylinders, the exhaust mixture from the lean and rich cylinder can be accurately controlled the desired mixture air/fuel ratio.

In an alternative embodiment, the above object is achieved, and disadvantages of prior approaches overcome, by a method for air/fuel ratio control of an exhaust gas mixture entering an emission control device, the emission control device located in an exhaust passage of an internal combustion engine having at least a first and second cylinder, the method comprising the steps of generating a desired air/fuel ratio difference between the first cylinder and the second cylinder so that a desired emission control device temperature is achieved, generating a desired lean air/fuel ratio for the first cylinder based on said desired air/fuel ratio difference and based on a desired air/fuel ratio of the exhaust gas mixture, wherein exhaust gasses from the first and second cylinders form the exhaust gas mixture, generating a desired rich air/fuel ratio for the second cylinder based on said desired air/fuel ratio difference and based on said desired air/fuel ratio of said exhaust gas mixture.

In this embodiment, the air/fuel ratio difference between the rich and lean cylinders is used to control trap temperature. Then, both the lean and rich cylinder air/fuel ratios are calculated from the air/fuel ratio difference and the desired exhaust mixture air/fuel ratio. Because the air/fuel ratio difference between the rich and lean cylinders is proportional to the heat addition to the trap, this parameter can be used to control trap temperature. Then, to provide the desired difference with a certain mixture air/fuel ratio, the desired rich and lean cylinder air/fuel ratio is accurately calculated.

The various embodiments of the invention offer the advantages of improved nitrous oxide trap durability. and improved nitrous oxide conversion efficiency.

The invention will now be described further, by way of example, with reference to the accompanying drawings, in which:

Figure 1 is a block diagram of an embodiment wherein the invention is used to advantage; and

Figures 2 - 10 are high level flow charts of various operations performed by a portion of the embodiment shown in Figure 1.

Figure 1 shows internal combustion engine 10, comprising multiple cylinders coupled to intake manifold 11. The engine cylinders are capable of operating within a range of air/fuel ratio ranging from a lean limit to a rich limit. Figure 1 shows two cylinders operating at a lean air/fuel ratio and two cylinders operating at a rich air/fuel ratio. The cylinders of engine 10 receive air from intake manifold 11 under control of throttle plate 14. The rich cylinders receive fuel from injectors 20 and 22. The lean cylinders receive fuel from injectors 24 and 26. The rich cylinders produce exhaust gas that has unburned hydrocarbons and carbon monoxide while the lean cylinders produce exhaust flow that has excess oxygen. The rich exhaust gas exits the rich cylinders through rich manifold 30 and pass through first three way catalyst 32. The lean exhaust gas exits the lean cylinders through lean manifold 34 and pass through second three way catalyst 36. Rich and lean gases then come together to form an exhaust mixture with a exhaust gas mixture air/fuel ratio before entering lean NOx trap 40. The catalytic activity of trap 40 promotes an exothermic chemical reaction from the exhaust mixture formed of both lean and rich gases, resulting in catalysed combustion, the generation of heat, and the increase of temperature of trap 40.

While the preferred embodiment employs two cylinders operating rich and an equal number of cylinders operating lean, various alternative embodiments are possible. For example, any total number of cylinders may be used with the number of lean and rich cylinders also being variable. For example, an 8 cylinder engine may have 5 cylinders operating lean with 3 cylinders operating rich. In either equally or unequally divided systems, the desired lean and rich air/fuel ratios are determined as will be described later herein with particular reference to Figures 2-10.

Controller 12 is shown in Figure 1 as a conventional microcomputer including: microprocessor unit 102, input/output ports 104, read-only memory 106, random access memory 108, and a conventional data bus. Controller 12 is shown receiving various signals from sensors 120 coupled to engine 10. In addition, controller 12 receives an indication of trap 40 temperature (T) from temperature sensor 42. Alternatively, temperature (T) may be estimated using various methods known to those skilled in the art. Controller 12 also sends signal fpwr to fuel injectors 20 and 22 and sends signal fpwl to fuel injectors 24 and 26.

Figures 2-9 are high level flow charts of various operations performed for desulfating trap 40. These routines are executed when it has been determined that proper conditions exist for trap desulfation. Various methods are known for determining entry conditions, such as, for example, when vehicle speed is greater than a predetermined value and nitrous oxide trapping efficiency is less than a predetermined value. Other conditions including engine speed, engine load, and gear ratio may be used. In general, trap desulfation is performed when trap 40 is saturated with sulphur and degraded operation has been detected or is suspected. Also, a minimum trap temperature is required to guarantee the that hydrocarbons and carbon monoxide will be oxidised by the excess oxygen as described later herein.

Referring now to Figure 2, a routine for projecting temperature (T) of trap 40 is described. First, in step 210, the actual temperature is read from sensor 42. As previously described herein, the actual trap temperature may be estimated using various methods known to those skilled in the art. Then, in step 212, the projected change in trap temperature (ΔT) is calculated based on the difference between the current temperature value (T) and the previous temperature value (Tpre) divided by the sample time (Δtime). Then, in step 214, the projected change in trap temperature (ΔT) is clipped between maximum and minimum values, where the maximum and minimum values are predetermined calibratable values. Then, in step 216, the clipped projected change in trap temperature (ΔT) is added to the current temperature value (T) to form the predicted temperature value (Tp). In step 218, the previous temperature (Tpre) is set to the current temperature value (T).

Referring now to Figure 3, a routine for determining a feedback amount for controlling trap temperature (T) to a desired temperature (Tdes) is described. In step 310, the desired desulfation temperature (Tdes) for the trap 40 is determined. In a preferred embodiment, this is a predetermined constant value. However, the desired temperature may be adjusted based on various factors, such as, for example, trap efficiency, trap age, or any other factor known to those skilled in the art to affect optimum temperature for desulfation. Then, in step 312, the temperature error (e) is calculated from the difference between desired temperature (Tdes) and predicted temperature (Tp). In step 314, the temperature error (e) is processed by a proportional and integral feedback controller (known to those skilled in the art as a PI controller) to generate a correction (λLFB) to the desired lean air/fuel ratio for the cylinders operating with lean combustion.

Referring now to Figure 4, a routine is described for calculating a feed forward correction value for the desired lean air/fuel ratio that accounts for engine load changes. First in step 410, the engine load is read. In a preferred embodiment, engine load is represented by the ratio of engine airflow, determined from, for example, a mass air flow meter, to engine speed. Then, in step 412, the desired lean air/fuel ratio adjustment (λLLA) due to engine load is calculated as the product of load and predetermined gain (Gl). The load correction is necessary because engine load has a strong influence on heat added to trap 40. For example, if the lean and rich cylinder air/fuel ratios are kept constant, but a large increase in airflow occurs, then substantially more heat is added to trap 40.

Referring now to Figure 5, a routine for determining a desired rich bias to add to the desired lean air/fuel ratio is determined. The desired rich bias is used for giving a slight rich bias to the mixture air/fuel ratio. This slightly rich mixture releases the stored sulphur oxide in the trap when the trap is at the proper desulfation temperature as described herein. In addition, this rich bias also creates additional exothermic heat which tends to further increase the trap temperature. To account for this in a feed forward fashion, the rich bias is also used to adjust (decrease) the desired difference in lean and rich air/fuel ratios. Thus, the additional heat added from the rich bias is counteracted in a feed forward way by providing less exothermic heat from the lean and rich exhaust gases. In this way, trap temperature can be more accurately controlled to a desired temperature, even when adding the rich bias.

First, in step 510, a determination is made as to whether trap temperature (T) is greater than or equal to the desired temperature (Tdes). If the answer to step 510 is NO, then the parameter (time_at_temp), which tracks the time duration the trap is at or above the desired temperature, is adjusted as shown in step 512. Otherwise, the parameter time_at_temp is adjusted as shown in step 514. Then, in step 516, a determination is made as to whether trap temperature (T) is greater than or equal to the desired temperature (Tdes) and if parameter time_at_temp is greater than predetermined value min_time. The value min_time represents the minimum time for which the trap temperature (T) is above or equal to the desired temperature (Tdes) before desulfation is allowed. If the answer to step 516 is NO, then the rich bias adjustment (λLRB) is set to zero in step 518. Otherwise, the rich bias adjustment value (λLRB) is calculated based on the desired rich bias (RB) and the parameter time_at_temp in step 520. In general, the time_at_temp value is used to allow the entire trap material to achieve the desired temperature (Tdes). For example, a rolling average filter may be used to calculated (λLRB).

Referring now to Figure 6, a routine for clipping the desired lean air/fuel ratio is described. First, in step 610, a determination is made as to whether the trap temperature (T) is greater than the sum of a lower control limit (TLO) and a safety factor (SF). If the answer to step 610 is NO, then in step 612, the temporary value (temp) is set to the stoichiometric air/fuel ratio (S). This prevents operation of some cylinders lean and some cylinders rich below the light off temperature of the trap. In other words, operating with lean and rich combustion for temperature control below a light off temperature will actually cause the temperature of trap 40 to reduce. This will give a reversal of controls and cause the controller to become unstable, resulting in degraded performance.

Continuing with Figure 6, if the answer to step 610 is YES, then in step 614, a determination is made as to whether trap temperature (T) is less than high temperature limit (high_limit), where high_limit is a temperature greater than the sum of lower control limit (TLO) and safety factor (SF). High_limit represents a limit below which closed loop control is not used to prevent poor controllability. If the answer to step 614 is YES, then in step 616, the temporary value (temp) is set to a predetermined constant value (λLL). This predetermined constant value accomplishes the following advantage. If closed loop temperature control is attempted below a certain temperature, the trap can initially cool below the light off temperature. Thus, unless the control is performed according to the present invention, an infinite cycle is encountered where trap temperature is never controlled to the desired temperature. Constant value (λLL) is determined based on experimental testing to provide a certain acceptable temperature increase rate of trap 40.

Continuing with Figure 6, if the answer to step 614 is NO, then temporary value (temp) is set to a the desired lean air/fuel ratio (λL) determined in step 710, described later herein with particular reference to Figure 7. Then, in step 619, the temporary value is clipped to a maximum limit value L1. Maximum limit value L1 represents the lean air/fuel ratio at which maximum incremental heat is added to increase trap temperature described later herein with particular reference to Figure 10. If the alternative embodiments are being employed, the maximum limit value can represent the rich air/fuel ratio, or the air/fuel ratio difference, at which maximum incremental heat is added to increase trap temperature. Additional limits may also be used to prevent the engine from experiencing engine misfire or other engine stability limits. For example, the maximum lean air/fuel ratio can be clipped based on engine mapping data so that engine misfire does not occur. In step 1020, the clipped desired lean air/fuel ratio is set to temporary value (temp).

As described herein, if the order of operations are reversed and the desired rich air/fuel ratio is first calculated, then the routine above can be used by simply substituting the desired rich air/fuel ratio for the desired lean air/fuel ratio and appropriate adjustment of the calibration parameters. Similarly, the air/fuel ratio span can be used by simple substitution. Referring now to Figure 7, the desired lean air/fuel ratio (λL) is calculated for controlling fuel injection to the lean cylinders, where the parameter λ indicates a relative air/fuel ratio, as is known to those skilled in the art. In step 710, the desired lean air/fuel ratio (λL) is calculated, where GRB is a predetermined gain. In a preferred embodiment, the desired lean air/fuel ratio (λL) is calculated as shown below:

$$\lambda L = (-\lambda LRB * GRB - \lambda LLA + \lambda LFB)$$

Referring now to Figure 8, the desired rich air/fuel ratio (λR) is calculated based on the desired lean air/fuel ratio. The desired rich air/fuel ratio is used for controlling fuel injection to the rich cylinders. First, in step 810, the clipped desired lean air/fuel ratio (λLd) is read from step 620 described previously herein with respect to Figure 6. Then, in step 812, the desired exhaust gas mixture air/fuel ratio (λdes) is determined, where again the parameter (λ) refers to a relative air/fuel ratio. In step 814, the ratio (R) of the number of lean cylinders to the number of rich cylinders is calculated. Then, in step 816, the desired rich air/fuel ratio (λR) is calculated according to the equation below:

$$\lambda R = \frac{\lambda des * \lambda Ld}{\lambda Ld(1+R) - \lambda des * R}$$

This equation can be simplified when the desired air/fuel ratio is stoichiometric and the ratio (R) is unity to the following equation:

$$\lambda R = \frac{\lambda Ld}{2 * \lambda Ld - 1}$$

In an alternative embodiment, the order of calculation can be reversed with respect the desired lean and rich air/fuel ratios. In other words, the desired rich air/fuel ratio can be calculated based on the feedback correction (λLFB), rich bias adjustment (λRB), and lean air/fuel ratio adjustment (λLLA) and clipped in a similar fashion to the desired lean air/fuel ratio. Then, the desired lean air/fuel ratio is calculated according to the following equation:

$$\lambda L = \frac{\lambda des * \lambda Rd * R}{\lambda Rd(1+R) - \lambda des}$$

In another alternative embodiment, the air/fuel ratio span, the difference between the lean air/fuel ratio and the rich air/fuel ratio, can be used to control trap temperature (T). In this case, the desired air/fuel ratio span (Δλ) is determined based on temperature error and the feed forward load correction and feed forward rich bias correction. The desired air/fuel ratio span (Δλ) can then be clipped in a similar fashion to the clipping of the desired lean air/fuel ratio. Then, the desired lean and rich air/fuel ratios can be determined as shown by the equations below:

$$\lambda L = \frac{1}{2}\left(\Delta\lambda d + \lambda des + \frac{\sqrt{R(\Delta\lambda d - \lambda des)^2 + (\Delta\lambda d + \lambda des)^2}}{\sqrt{R+1}} \right)$$

For the simple case where the desired exhaust gas mixture air/fuel ratio (λdes) is stoichiometric and the ratio (R) is unity then the following simpler equation can be used:

$$\lambda L = \frac{1}{2} + \frac{\Delta\lambda d}{2} + \frac{\sqrt{1+(\Delta\lambda d)^2}}{2}$$

Then, the desired rich air/fuel ratio is calculated simply from the following equation:

$$\lambda R = \lambda L - \Delta\lambda d$$

Referring now to Figure 9, a routine for calculating fuel pulse width signals (fpwL and fpwR) is described. In step 910, the lean fuel pulse width is calculated based on engine airflow from the mass air flow sensor (MAF), the number of lean and rich cylinders, the stoichiometric air/fuel ratio (S), and the desired lean air/fuel ratio (λL). Then, in step 912, the rich fuel pulse width is calculated based on engine airflow from the mass air flow sensor (MAF), the number of lean and rich cylinders, the stoichiometric air/fuel ratio (S), and the desired rich air/fuel ratio (λR) and the rich bias correction (λLRB).

Referring now to Figure 10, a graph is shown representing an approximate relationship between incremental heat added to the trap versus lean air/fuel ratio (λL), air/fuel ratio difference ($\Delta\lambda$), or inverted rich air/fuel ratio $(\lambda R)^{-1}$. The graph shows that a certain value represents a maximum heat addition. Increasing beyond this point results in less, or even negative, heat addition to the trap. Thus, the control should be limited to the value L1, to prevent control instabilities and less than optimal control. The incremental heat addition to the trap may be determined relative to stoichiometry. The incremental heat addition takes into account both the cooling off of engine out exhaust gas temperature due to operation away from stoichiometry as well as the heat addition from the exothermic reaction proportional to the difference in the lean and rich air/fuel ratios.

Although several examples of embodiments which practice the invention have been described herein, there are numerous other examples which could also be described. For example, the invention may be used to advantage with both direct injection engines in which nitrous oxide traps may be used.

CLAIMS

1. A method for air/fuel ratio control of an exhaust gas mixture entering an emission control device, the emission control device located in an exhaust passage of an internal combustion engine having at least a first and second cylinder, the method comprising the steps of:

generating a desired lean air/fuel ratio for the first cylinder so that a desired emission control device temperature is achieved;

operating the first cylinder at said desired lean air/fuel ratio;

generating a desired rich air/fuel ratio for the second cylinder based on said desired lean air/fuel ratio and based on a desired air/fuel ratio of the exhaust gas mixture, wherein exhaust gasses from the first and second cylinders form the exhaust gas mixture; and

operating the second cylinder at said desired rich air/fuel ratio.

2. A method as claimed in Claim 1, further comprising the step of setting said desired mixture air/fuel ratio rich of stoichiometry when said desired emission control device temperature is achieved, thereby purging sulphur from the device.

3. A method as claimed in Claim 1, further comprising the steps of:

enriching said desired lean air/fuel ratio when said desired emission control device temperature is achieved; and

setting said desired mixture air/fuel ratio rich of stoichiometry when said desired emission control device temperature is achieved.

4. A method as claimed in Claim 1, wherein said desired mixture air/fuel ratio is stoichiometry and said emission control device is a NOx trap.

5. A method as claimed in Claim 1, wherein said step of generating said desired lean air/fuel ratio for the first cylinder further comprises generating said desired lean air/fuel ratio for the first cylinder based on a deviation between said desired emission control device temperature and an actual emission control device temperature.

6. A method for air/fuel ratio control of an exhaust gas mixture entering an emission control device, the emission control device located in an exhaust passage of an internal combustion engine having at least a first and second cylinder, the method comprising the steps of:

generating a desired rich air/fuel ratio for the first cylinder so that a desired emission control device temperature is achieved;

operating the first cylinder at said desired rich air/fuel ratio;

generating a desired lean air/fuel ratio for the second cylinder based on said desired rich air/fuel ratio and based on a desired air/fuel ratio of the mixture of exhaust gasses, wherein exhaust gasses from the first and second cylinders form the exhaust gas mixture; and

operating the second cylinder at said desired lean air/fuel ratio.

7. A method as claimed in Claim 6, further comprising the step of setting said desired mixture air/fuel ratio rich of stoichiometry when said desired emission control device

temperature is achieved, thereby purging sulphur from the device.

8. A method as claimed in Claim 6, further comprising the steps of:

enleaning said desired rich air/fuel ratio when said desired emission control device temperature is achieved; and

setting said desired mixture air/fuel ratio rich of stoichiometry when said desired emission control device temperature is achieved.

9. A method as claimed in Claim 6, wherein said desired mixture air/fuel ratio is stoichiometry and said emission control device is a NOx trap.

10. A method as claimed in Claim 6, wherein said step of generating said desired rich air/fuel ratio for the first cylinder further comprises generating said desired rich air/fuel ratio for the first cylinder based on a deviation between said desired emission control device temperature and an actual emission control device temperature.

11. A method for air/fuel ratio control of an exhaust gas mixture entering an emission control device, the emission control device located in an exhaust passage of an internal combustion engine having at least a first and second cylinder, the method comprising the steps of:

generating a desired air/fuel ratio difference between the first cylinder and the second cylinder so that a desired emission control device temperature is achieved;

generating a desired lean air/fuel ratio for the first cylinder based on said desired air/fuel ratio difference and based on a desired air/fuel ratio of the exhaust gas mixture, wherein exhaust gasses from the first and second cylinders form the exhaust gas mixture;

generating a desired rich air/fuel ratio for the second cylinder based on said desired air/fuel ratio difference and based on said desired air/fuel ratio of said exhaust gas mixture;

operating the first cylinder at said desired lean air/fuel; and

operating the second cylinder at said desired rich air/fuel ratio.

12. A method as claimed in Claim 11, further comprising the step of setting said desired mixture air/fuel ratio rich of stoichiometry when said desired emission control device temperature is achieved, thereby purging sulphur from the device.

13. A method as claimed in Claim 11, further comprising the steps of:

decreasing said desired air/fuel ratio difference when said desired emission control device temperature is achieved; and

setting said desired mixture air/fuel ratio rich of stoichiometry when said desired emission control device temperature is achieved.

14. A method as claimed in Claim 11, wherein said desired mixture air/fuel ratio is stoichiometry and said emission control device is a NOx trap.

15. A method as claimed in Claim 11, wherein said step of generating said desired air/fuel ratio difference further comprises generating said desired air/fuel ratio difference

based on a deviation between said desired emission control device temperature and an actual emission control device temperature.

16. An article of manufacture comprising:

a computer storage medium having a computer program encoded therein for controlling the amount of fuel supplied to at least a first cylinder and a second cylinder of an engine, the engine having an exhaust passage with a NOx trap located therein, said computer storage medium comprising:

code for determining a desired air/fuel ratio of said first cylinder based on a desired trap temperature and an actual trap temperature; and

code for generating a desired air/fuel ratio for the second cylinder based on said first cylinder desired air/fuel ratio and based on a desired mixture air/fuel ratio of exhaust gasses, wherein exhaust gasses from said first and second cylinders form said exhaust gas mixture.

17. An article as claimed in Claim 16, wherein said medium further comprises:

code for setting said desired mixture air/fuel ratio rich of stoichiometry when said desired trap temperature is achieved.

18. An article as claimed in Claim 16, wherein said medium further comprises:

code for changing operation of said first cylinder desired air/fuel ratio toward stoichiometry when said desired trap temperature is achieved; and code for setting said desired mixture air/fuel ratio rich of stoichiometry when said trap temperature is achieved.

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Application No:	GB 0011870.3	**Examiner:**	Dr Albert Mthupha
Claims searched:	1-18	**Date of search:**	30 October 2000

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Databases searched:

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Other: ONLINE: EPODOC, JAPIO, WPI.

Documents considered to be relevant:

Category	Identity of document and relevant passage		Relevant to claims
X	GB 2316338 A	ROVER, see page 1 line 15-page 7 line 22.	1, 6 at least.
X	US 5661971 A	VOLKSWAGEN, see column 2 lines 18-42, column 3 line 37-column 4 line 26, Claims 1, 6 & 7.	1, 6 at least.
X	US 5657625 A	MITSUBISHI, see whole document particularly Claims 1, 5 9, 10, 11, 12,	1, 2, 4, 6, 8, 9 at least.

X	Document indicating lack of novelty or inventive step	A	Document indicating technological background and/or state of the art.
Y	Document indicating lack of inventive step if combined with one or more other documents of same category.	P	Document published on or after the declared priority date but before the filing date of this invention.
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