(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
11 September 2015 (11.09.2015)

WIPO | PCT

(10) International Publication Number
WO 2015/132644 A1

(51) International Patent Classification:
F01N 9/00 (2006.01) *F02D 41/00* (2006.01)
F01N 3/10 (2006.01) *F02D 11/10* (2006.01)
F02D 41/14 (2006.01) *F02D 41/02* (2006.01)

(21) International Application Number:
PCT/IB2015/000249

(22) International Filing Date:
27 February 2015 (27.02.2015)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
2014-043206 5 March 2014 (05.03.2014) JP

(71) Applicant: **TOYOTA JIDOSHA KABUSHIKI KAISHA** [JP/JP]; 1, Toyota-cho, Toyota-shi, Aichi-ken, 471-8571 (JP).

(72) Inventor: **GOTO, Isamu**; c/o TOYOTA JIDOSHA KABUSHIKI KAISHA, of 1, Toyota-cho, Toyota-shi, Aichi-ken, 471-8571 (JP).

(81) Designated States *(unless otherwise indicated, for every kind of national protection available)*: AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IR, IS, KE, KG, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

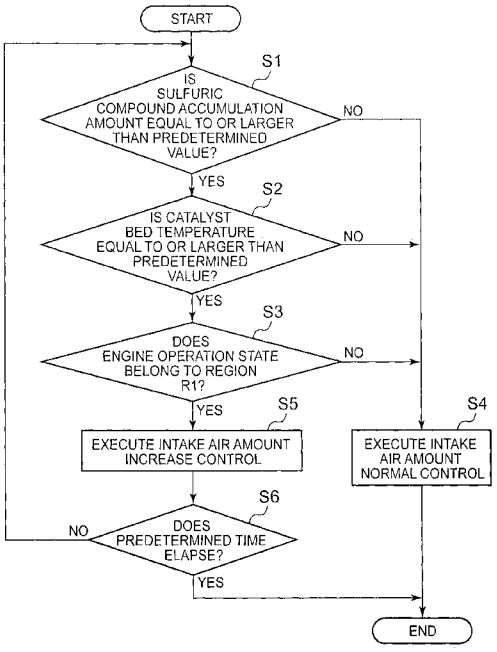
(84) Designated States *(unless otherwise indicated, for every kind of regional protection available)*: ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, ST, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, KM, ML, MR, NE, SN, TD, TG).

Published:
— *with international search report (Art. 21(3))*

[Continued on next page]

(54) Title: CONTROL APPARATUS FOR INTERNAL COMBUSTION ENGINE SUPPRESSING WHITE SMOKE EMISSIONS

FIG. 4



(57) Abstract: A control apparatus for an internal combustion engine is provided. The control apparatus includes a temperature sensor and an electronic control unit. The temperature sensor is configured to detect the temperature of an exhaust gas control apparatus. The electronic control unit is configured to: (a) estimate a sulfuric compound accumulation amount on the exhaust gas control apparatus; and (b) when a specific condition in which the sulfuric compound accumulation amount is equal to or larger than a predetermined accumulation amount (S1) and the temperature of the exhaust gas control apparatus is equal to or higher than a predetermined temperature or more (S2) is satisfied, control an intake air amount adjuster such that an intake air amount when the specific condition is satisfied is increased (S5) as compared to the intake air amount when the specific condition is not satisfied in the same operation state (S4).

WO 2015/132644 A1

— *before the expiration of the time limit for amending the claims and to be republished in the event of receipt of amendments (Rule 48.2(h))*

CONTROL APPARATUS FOR INTERNAL COMBUSTION ENGINE SUPPRESSING WHITE SMOKE EMISSIONS

BACKGROUND OF THE INVENTION

1. Field of the Invention

[0001] The invention relates to a control apparatus for an internal combustion engine.

2. Description of Related Art

[0002] In some cases, a sulfuric compound in an exhaust gas may be accumulated on an exhaust gas control apparatus such as a catalyst. Japanese Patent Application Publication No. 2010-229916 (JP 2010-229916 A) discloses a sulfur poisoning regeneration control that separates sulfur accumulated on a catalyst. Further, Japanese Patent Application Publication No. 7-247916 (JP 7-247916 A), Japanese Patent Application Publication No. 2004-245046 (JP 2004-245046 A), and Japanese Patent Application Publication No. 2011-132836 (JP 2011-132836 A) also disclose techniques for regenerating a catalyst.

SUMMARY OF THE INVENTION

[0003] When an accumulated sulfuric compound is separated from an exhaust gas control apparatus, an exhaust gas may be visibly recognized as white smoke. When such white smoke is visibly recognized, for example, a user may feel anxious.

[0004] The invention provides a control apparatus for an internal combustion engine in which white smoke is not easily and visibly recognized.

[0005] According to an aspect of the invention, there is provided a control apparatus for an internal combustion engine, the internal combustion engine including an exhaust gas control apparatus provided in an exhaust system of the internal combustion engine and an intake air amount adjuster adjusting an intake air amount with respect to the internal combustion engine. The control apparatus includes a temperature sensor and an electronic control unit. The temperature sensor is

CONFIRMATION COPY

configured to detect the temperature of the exhaust gas control apparatus. The electronic control unit is configured to: (a) estimate a sulfuric compound accumulation amount, the sulfuric compound accumulation amount being an amount of a sulfuric compound accumulated on the exhaust control apparatus; and (b) when a specific condition in which the sulfuric compound accumulation amount is equal to or larger than a predetermined accumulation amount and the temperature of the exhaust gas control apparatus is equal to or higher than a predetermined temperature or more is satisfied, control the intake air amount adjuster such that the intake air amount when the specific condition is satisfied is increased as compared to the intake air amount when the specific condition is not satisfied in the same operation state.

[0006] The electronic control unit may be configured to, when the specific condition is satisfied and the operation state of the internal combustion engine is in a predetermined region, control the intake air amount adjuster such that the intake air amount when the specific condition is satisfied is increased as compared to the intake air amount when the specific condition is not satisfied in the same operation state. The electronic control unit may be configured to, when the specific condition is satisfied and the operation state of the internal combustion engine is in a high load side region or a high rotation speed side region compared to the predetermined region, control the intake amount such that the intake air amount when the specific condition is satisfied is not increased as compared to the intake air amount when the specific condition is not satisfied in the same operation state.

[0007] The air intake amount adjuster may be at least one of a throttle valve, an exhaust gas recirculation valve, and a variable nozzle vane of an exhaust turbine of a turbocharger, and an intake air amount increase control may employ at least one of a control of controlling the throttle valve to an opening side, a control of controlling the exhaust gas recirculation valve to a closing side, and a control of controlling the variable nozzle vane to a closing side.

[0008] It is possible to provide the control apparatus for the internal combustion engine in which white smoke is not easily and visibly recognized.

BRIEF DESCRIPTION OF THE DRAWINGS

[0009] Features, advantages, and technical and industrial significance of exemplary embodiments of the invention will be described below with reference to the accompanying drawings, in which like numerals denote like elements, and wherein:

FIG. 1 is a diagram illustrating an engine system of an embodiment;

FIG. 2A is a graph illustrating the concentration of a sulfuric compound contained in an exhaust gas when white smoke is generated;

FIG. 2B is a graph illustrating an engine rotation speed when white smoke is generated;

FIG. 2C is a graph illustrating an intake air amount when white smoke is generated;

FIG. 2D is a graph illustrating a catalyst bed temperature when white smoke is generated;

FIG. 3 is a map illustrating a region in which white smoke is visibly recognized and a region in which white smoke is not visibly recognized; and

FIG. 4 is a flowchart illustrating an example of a control executed by an ECU.

DETAILED DESCRIPTION OF EMBODIMENTS

[0010] FIG. 1 is a diagram illustrating an engine system 10 according to an embodiment. A diesel engine (hereinafter, referred to as an engine) 11 includes an intake manifold 12 and an exhaust manifold 13. The intake manifold 12 is connected to an outlet of a compressor 16 of a turbocharger 15 through an intake passageway 14. The intake passageway 14 is equipped with an intercooler IC that cools intake air and a throttle valve V that adjusts an air intake amount with respect to the engine 11. The exhaust manifold 13 is connected to an inlet of an exhaust turbine 18 of the turbocharger 15 through an exhaust passageway 17. A variable nozzle vane 18a is provided at the inlet of the exhaust turbine 18. The flow rate of the exhaust gas that passes through the exhaust turbine 18 may be adjusted in response to the opening degree of the variable nozzle vane 18a. The outlet of the exhaust turbine 18 is

connected to an exhaust passageway 19. The exhaust gas that is generated from the engine 11 is discharged to the exhaust passageway 19 through the exhaust turbine 18. The engine 11 includes four cylinders C and four fuel injection valves F that directly and respectively inject fuel into the four cylinders C, but the invention is not limited thereto. An EGR (Exhaust Gas Recirculation) passageway 14a is connected between the intake passageway 14 and the exhaust passageway 17. The EGR passageway 14a is equipped with an EGR valve Va. The engine 11 is equipped with a crank angle sensor CS that detects the engine rotation speed.

[0011] The exhaust passageway 19 is equipped with an exhaust gas control apparatus E that purifies an exhaust gas. A DOC (Diesel Oxidation Catalyst) 20 and a DPF (Diesel Particulate Filter) 21 are provided inside the exhaust gas control apparatus E in order from the upstream side to the downstream side. The DOC 20 is an oxidation catalyst that oxidizes HC and NO contained in the exhaust gas so as to be converted into H_2O and CO_2. The DPF 21 traps a particulate matter contained in the exhaust gas. The exhaust gas control apparatus E is an example of the exhaust gas control apparatus.

[0012] A fuel adding valve 24, a SOx sensor 25, and a temperature sensor 26 are provided in the exhaust passageway 19 between the exhaust turbine 18 and the DOC 20. The SOx sensor 25 detects a sulfur concentration in the exhaust gas flowing through the DOC 20. Furthermore, a fuel property sensor may be provided in a fuel tank instead of the SOx sensor 25 so as to directly detect the sulfur concentration in fuel. The fuel adding valve 24 adds fuel used to burn the PM (Particulate Matter) accumulated on the DPF 21 into the exhaust gas. The temperature sensor 26 detects the temperature of the exhaust gas flowing into the DOC 20.

[0013] A temperature sensor 27 is provided in the exhaust passageway 19 between the DOC 20 and the DPF 21. The temperature sensor 27 detects the temperature of the exhaust gas which passes through the DOC 20 and flows into the DPF 21. A temperature sensor 28 and an air-fuel ratio sensor 29 are provided in the exhaust passageway 19 at the downstream side of the DPF 21. The temperature sensor

28 detects the temperature of the exhaust gas passing through the DPF 21. The air-fuel ratio sensor 29 detects the air-fuel ratio of the exhaust gas that passes through the DPF 21.

[0014] An ECU (Electronic Control Unit) 30 controls the entire engine system 10. The ECU 30 is a computer including a ROM (Read Only Memory), a RAM (Random Access Memory), a CPU (Central Processing Unit), and the like which are not shown in the drawings. The ECU 30 is electrically connected to the throttle valve V and the EGR valve Va, or the above-described sensors.

[0015] The ECU 30 estimates the amount of the sulfuric compound accumulated on the DOC 20 and the DPF 21. Specifically, since the sulfuric compound accumulation amount is involved with the fuel amount consumed by the engine 11, the ECU 30 estimates the sulfuric compound accumulation amount based on the fuel consumption amount consumed by the engine 11. However, the sulfuric compound accumulation amount may be estimated by the other method. Further, the ECU 30 may store in advance the sulfur concentration in fuel used in a place where the engine system 10 is used and estimate the sulfuric compound accumulation amount in consideration of the sulfur concentration. Further, the sulfuric compound accumulation amount may be estimated in consideration of the sulfur concentration in fuel estimated based on the output values obtained from the SOx sensor 25 and the like. The ECU 30 is an example of an estimation unit that estimates the sulfuric compound accumulation amount of the exhaust gas control apparatus.

[0016] The ECU 30 detects the temperature, that is, the catalyst bed temperature of the exhaust gas control apparatus E based on the measurement values of the temperature sensors 26, 27, and 28. Furthermore, the temperature may be detected by directly installing the temperature sensors in the DOC 20 and the DPF 21. Each of the temperature sensors 26, 27, and 28 is an example of a detection unit that detects the temperature of the exhaust gas control apparatus. Furthermore, the catalyst bed temperature may be estimated from the operation state of the engine 11.

[0017] Next, a case will be described in which the exhaust gas is visibly

recognized as white smoke. FIGS. 2A to 2D are graphs illustrating various values when white smoke is generated. The vertical axis of FIG. 2A indicates the concentration of the sulfuric compound contained in the exhaust gas. In FIG. 2A, the allowable limit value in which the exhaust gas is not visibly recognized as white smoke is indicated by the dotted line. The vertical axis of FIG. 2B indicates the engine rotation speed. The vertical axis of FIG. 2C indicates the intake air amount. The vertical axis of FIG. 2D indicates the catalyst bed temperature. The horizontal axes of FIGS. 2A to 2D indicate the elapse time.

[0018] A case will be supposed in which a certain degree of the sulfuric compound is accumulated on the DOC 20 and the DPF 21 and the rotation speed of the engine 11 gradually increases so that the catalyst bed temperature gradually increases. When the rotation speed of the engine 11 increases, the intake air amount increases, the operation state of the engine 11 belongs to a region R1 which will be described later, and the catalyst bed temperature increases as shown in FIGS. 2B to 2D, the sulfuric compound concentration in the exhaust gas becomes close to the allowable limit value as shown in FIG. 2A. When the catalyst bed temperature further increases as shown in FIG. 2D, the sulfuric compound concentration exceeds the allowable limit value so that the exhaust gas is visibly recognized as white smoke as shown in FIG. 2A. The reason is assumed that the amount of the sulfuric compound (SOx) separated from the DOC 20 and the DPF 21 increases when the catalyst bed temperature reaches a predetermined value or more and SO_3in the exhaust gas is combined with H_2O so as to become mist of H_2SO_4 and is discharged as white smoke. For example, such white smoke may be generated when the temperature of the exhaust gas increases in a case where the vehicle climbs a hill or when the temperature of the DOC 20 and the DPF 21 becomes a high temperature during the execution of a PM regeneration control.

[0019] FIG. 3 is a map illustrating a region R1 in which white smoke is visibly recognized and a region R2 in which white smoke is not visibly recognized. In this map, the vertical axis indicates the load of the engine 11, and the horizontal axis indicates the rotation speed of the engine 11. This map is prepared in advance by an

experiment or the like, and is stored in the ROM of the ECU 30. There is a case where the exhaust gas is not visibly recognized as white smoke even when the DOC 20 and the DPF 21 become hot while a predetermined value or more of the sulfuric compound is accumulated on the DOC 20 and the DPF 21 in accordance with the operation state of the engine 11.

[0020] For example, when the operation state belongs to the region R2 of which the engine rotation speed is higher than that of the region R1, the flow rate of the exhaust gas is fast. Accordingly, the sulfuric compound concentration in the exhaust gas also decreases, and hence white smoke is not easily and visibly recognized. Further, in this case, the vehicle speed is also fast in many cases, and hence white smoke is not easily and visibly recognized. In addition, when the operation state belongs to the region R2 of which the load is higher than that of the region R1, the fuel injection amount increases and the temperature of the exhaust gas becomes a high temperature. For this reason, it is considered that the moisture as one factor of the white smoke evaporates before the exhaust gas is discharged from the exhaust passageway 17 to the outside. Furthermore, when the operation state belongs to the region R2 of which the engine load or the rotation speed is lower than that of the region R1, the amount of the sulfuric compound separated from the DOC 20 is small due to the low temperature of the DOC 20. For this reason, white smoke is not easily and visibly recognized.

[0021] In the embodiment, the intake air amount is increased when the condition of visibly recognizing white smoke is satisfied so that white smoke is diluted. As a result, the white smoke is not easily and visibly recognized due to the dilution of the white smoke. In FIGS. 2A and 2C, the sulfuric compound concentration and the intake air amount obtained when the intake air amount increases are indicated by the dotted line.

[0022] FIG. 4 is a flowchart illustrating an example of a control executed by the ECU 30. The ECU 30 determines whether the sulfuric compound accumulation amount of the DOC 20 and the DPF 21 is equal to or larger than a predetermined value (step S1). The predetermined value is a value of the sulfuric compound accumulation

amount of the DOC 20 and the DPF 21 when the exhaust gas is visibly recognized as white smoke due to the separation of the sulfuric compound accumulated on the DOC 20 and the DPF 21 in a case where the operation state of the engine 11 belongs to the region R1 and the temperature of the DOC 20 and the DPF 21 falls within a predetermined range.

[0023] When a positive determination is made in step S1, the ECU 30 determines whether the catalyst bed temperature is equal to or higher than a predetermined value (step S2). The predetermined value indicates a value of the catalyst bed temperature at which the exhaust gas starts to be visibly recognized as white smoke due to the separation of the sulfuric compound in a case where the operation state of the engine 11 belongs to the region R1 and the sulfuric compound accumulation amount of the DOC 20 and the DPF 21 is equal to or larger than the predetermined value.

[0024] The ECU 30 determines whether the operation state of the engine 11 belongs to the region R1 (step S3). Specifically, the ECU 30 recognizes the operation state of the engine based on the fuel injection amount and the rotation speed of the engine 11, and determines whether the operation state of the engine 11 belongs to the region R1 shown in the map of FIG. 3. Furthermore, the processes of step S1 to step S3 correspond to the processes used to determine whether the condition of generating white smoke is satisfied.

[0025] When a negative determination is made in any one of step S1 to step S3, the ECU 30 executes an intake air amount normal control (hereinafter, referred to as a normal control) (step S4). The normal control indicates a control of adjusting the opening degrees of the EGR valve Va or the throttle valve V so that the intake air amount reaches a target intake air amount corresponding to the requested operation state of the engine 11. White smoke is not generated when a negative determination is made in any one of step S1 and step S2 or white smoke is not easily and visibly recognized when a negative determination is made in step S3. For this reason, in this case, no problem arises even when the intake air amount is controlled by a normal

method. The normal control is a control executed when the condition of generating white smoke is not satisfied. A series of the control ends after the normal control is executed.

[0026] A case where a positive determination is made in all step S1 to step S3 corresponds to a case where generated white smoke may be visibly recognized. In this case, the ECU 30 executes an intake air amount increase control (hereinafter, referred to as an amount increase control) (step S5). In the amount increase control, the intake air amount is made to become larger than the intake air amount set when the normal control is executed at the same operation condition as the operation state in the amount increase control. Specifically, the opening degree of the throttle valve V is set so that the throttle valve V is fully opened, and the opening degree of the EGR valve Va is set so that the EGR valve Va is fully closed. Thus, fresh air introduced into the engine 11 increases in amount, and the amount of the exhaust gas flowing back to the inlet of the engine 11 substantially becomes zero. Accordingly, the intake air amount increases as indicated by the dotted line of FIGS. 2A and 2C, and the exhaust gas amount also increases so that white smoke is diluted. As a result, the white gas is not easily and visibly recognized due to the dilution of the white gas. The throttle valve V and the EGR valve Va are examples of an air intake amount adjuster that adjusts the intake air amount.

[0027] Next, the ECU 30 determines whether the amount increase control execution period elapses by a predetermined period (step S6). Here, the predetermined period is a period which is sufficiently set so that the sulfuric compound accumulated on the DOC 20 and the DPF 21 is entirely separated. When a positive determination is made in step S6, the control ends. When the control ends, the sulfuric compound accumulation amount of the DOC 20 and the DPF 21 is reset to zero. In the process of step S1 when the control is executed again, the sulfuric compound accumulation amount is estimated based on the fuel consumption amount after the accumulation amount is reset.

[0028] When a negative determination is made in step S6, the ECU 30

executes a process after step S1. Furthermore, in this case, in the process of step S1 in which the control is executed again, the ECU 30 estimates the current sulfuric compound accumulation amount in consideration of the sulfuric compound separated from the DOC 20 and the DPF 21 during an actual period of an amount increase control.

[0029] As described above, it is possible to suppress a problem in which a user who visibly recognizes white smoke feels uncomfortable by executing the amount increase control when the condition of generating white smoke is satisfied. Further, it is possible to suppress an influence on the drivability by executing the normal control when the condition is not satisfied.

[0030] Furthermore, the amount increase control is not limited to the control in which the throttle valve V is adjusted to be fully opened and the EGR valve Va is adjusted to be fully closed. For example, the opening degree of the throttle valve V in the amount increase control may be controlled to the opening side compared to the opening degree of the throttle valve V set in the normal control in the same operation state as the amount increase control. Similarly, the opening degree of the EGR valve Va in the amount increase control may be controlled to the closing side compared to the opening degree of the EGR valve Va set in the normal control in the same operation state as the amount increase control. Even in this case, the intake air amount may be increased compared to the normal control.

[0031] In the amount increase control, only the opening degree of the throttle valve V may be controlled to the opening side compared to the normal control, and the opening degree of the EGR valve Va may be continuously subjected to the normal control. Further, only the opening degree of the EGR valve Va may be controlled to the closing side compared to the normal control, and the opening degree of the throttle valve V may be continuously subjected to the normal control in the engine 11.

[0032] The opening degree of the variable nozzle vane 18a in the amount increase control may be controlled to the closing side compared to the opening degree of the variable nozzle vane 18a set in the normal control in the same operation state as the amount increase control. Thus, the supercharging pressure decreases, and hence

the intake air amount with respect to the engine 11 may be increased. Accordingly, the amount increase control may be at least one of the control of controlling the throttle valve V to the opening side, the control of controlling the EGR valve Va to the closing side, and the control of controlling the variable nozzle vane 18a to the closing side.

[0033] The amount increase control may be executed in synchronization with an increase in the temperature of the DPF 21 during the execution of the PM regeneration control of burning the PM accumulated on the DPF 21 by igniting the fuel added from the fuel adding valve 24 to the exhaust gas.

[0034] The correction may be performed so that the amount increase control execution period increases as the sulfur concentration of fuel increases. Further, the correction may be performed so that the intake air amount increases as the sulfur concentration of fuel increases. In general, as the sulfur concentration of fuel increases, the white smoke discharge period increases and the sulfur concentration in the exhaust gas increases so that the white smoke is easily and visibly recognized. Further, the region R1 may be widened as the sulfur concentration of fuel increases.

[0035] Furthermore, the temperature of the DOC 20 and the DPF 21 may be slightly decreased by increasing the intake air amount. Even in this configuration, it is possible to prevent a problem in which a user may not easily and visibly recognize white smoke by suppressing the separation of the sulfuric compound from the DOC 20 and the DPF 21 and the generation of white smoke.

[0036] The above-described embodiment is merely an example of implementing the invention, and the invention is not limited thereto. For the description above, it is apparent that various modifications of the embodiment are included in the scope of the invention and various embodiments may be employed in the scope of the invention.

CLAIMS:

1. A control apparatus for an internal combustion engine, the internal combustion engine including an exhaust gas control apparatus provided in an exhaust system of the internal combustion engine and an intake air amount adjuster configured to adjust an intake air amount of the internal combustion engine, the control apparatus comprising:

a temperature sensor configured to detect the temperature of the exhaust gas control apparatus; and

an electronic control unit configured to:

(a) estimate a sulfuric compound accumulation amount, the sulfuric compound accumulation amount being an amount of a sulfuric compound accumulated on the exhaust control apparatus; and

(b) when a specific condition in which the sulfuric compound accumulation amount is equal to or larger than a predetermined accumulation amount and the temperature of the exhaust gas control apparatus is equal to or higher than a predetermined temperature or more is satisfied, control the intake air amount adjuster such that the intake air amount when the specific condition is satisfied is increased as compared to the intake air amount when the specific condition is not satisfied in the same operation state.

2. The control apparatus according to claim 1, wherein

the electronic control unit is configured to ,when the specific condition is satisfied and the operation state of the internal combustion engine is in a predetermined region, control the intake air amount adjuster such that the intake air amount when the specific condition is satisfied is increased as compared to the intake air amount when the specific condition is not satisfied in the same operation state, the electronic control unit is configured to, when the specific condition is satisfied and the operation state of the internal combustion engine is in a high load side region or a high rotation speed side region compared to the predetermined region, control the intake amount such that the

intake air amount when the specific condition is satisfied is not increased as compared to the intake air amount when the specific condition is not satisfied in the same operation state.

3. The control apparatus according to claim 1 or 2, wherein

the intake air amount adjuster is a throttle valve, and

the electronic control unit is configured to control the throttle valve to an opening side so as to increase the intake air amount.

4. The control apparatus according to claim 1 or 2, wherein

the intake air amount adjuster is an exhaust gas recirculation valve, and

the electronic control unit is configured to control the exhaust gas recirculation valve to a closing side so as to increase the intake air amount.

5. The control apparatus according to claim 1 or 2, wherein

the intake air amount adjuster is a variable nozzle vane of an exhaust turbine of a turbocharger, and

the electronic control unit is configured to control the variable nozzle vane to a closing side so as to increase the intake air amount.

FIG. 1

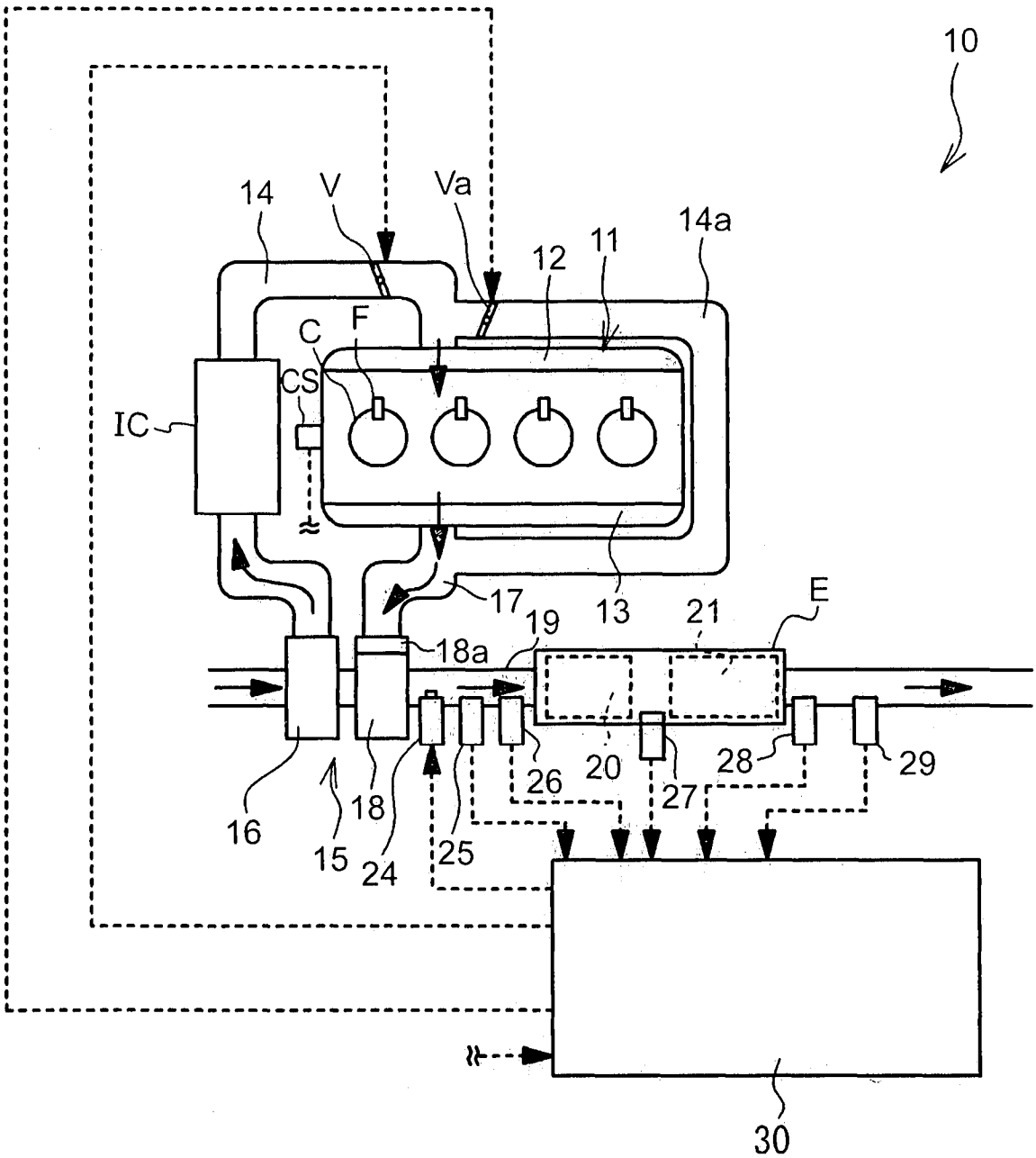

10
14
V
Va
12
11
14a
C
F
CS
IC
17
19
13
21
E
18a
16
18
15
24
25
26
20
27
28
29
30

FIG. 2A

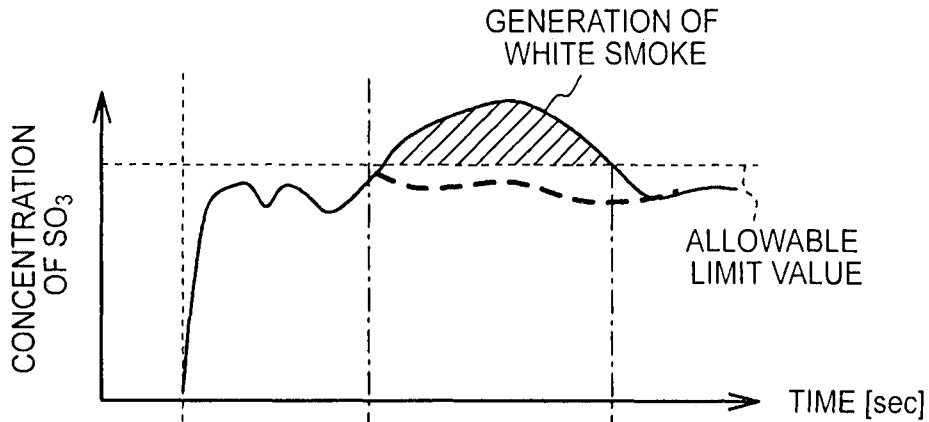


FIG. 2B

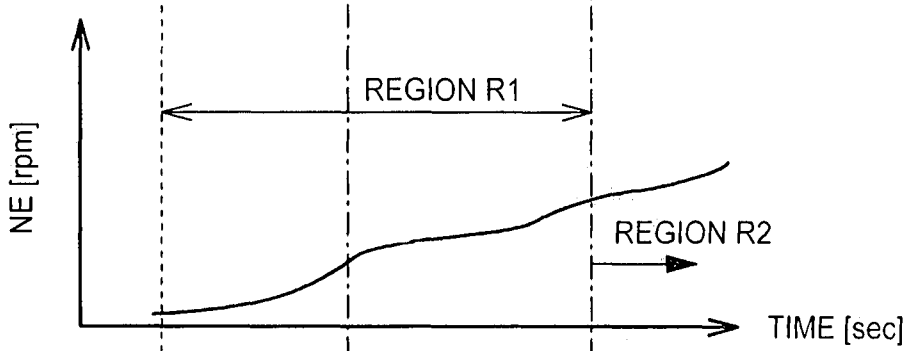


FIG. 2C

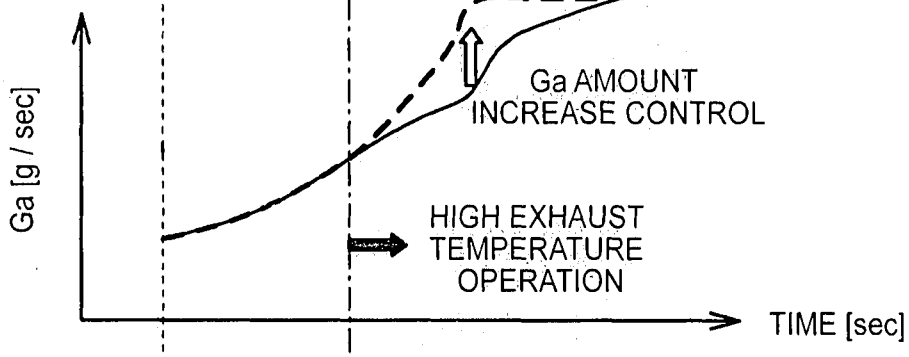


FIG. 2D

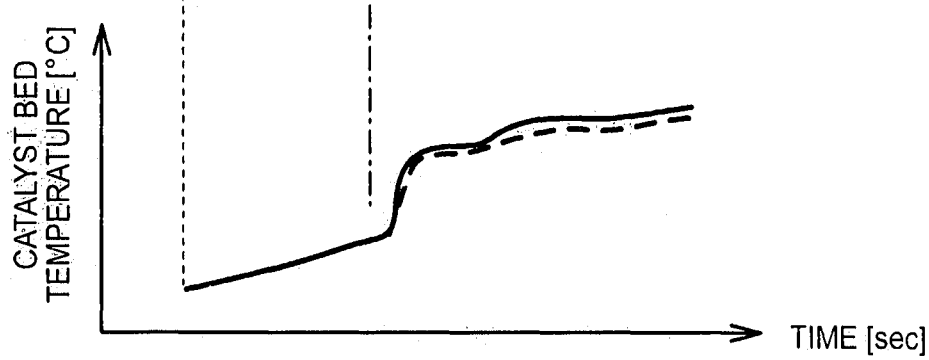


FIG. 3

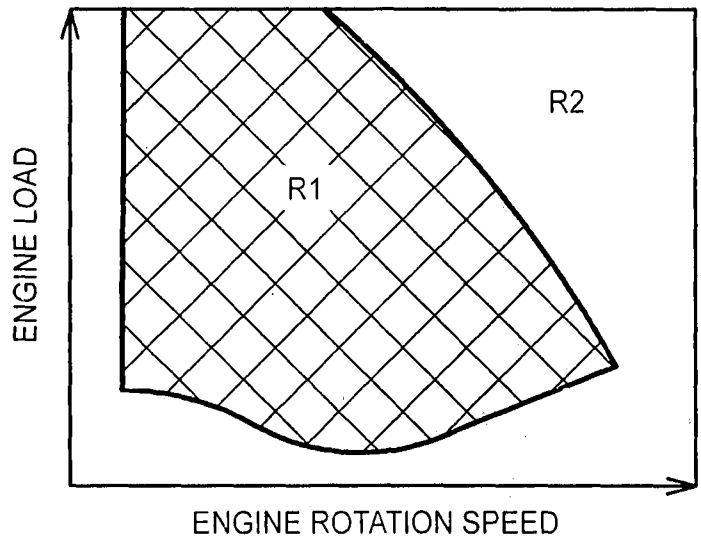
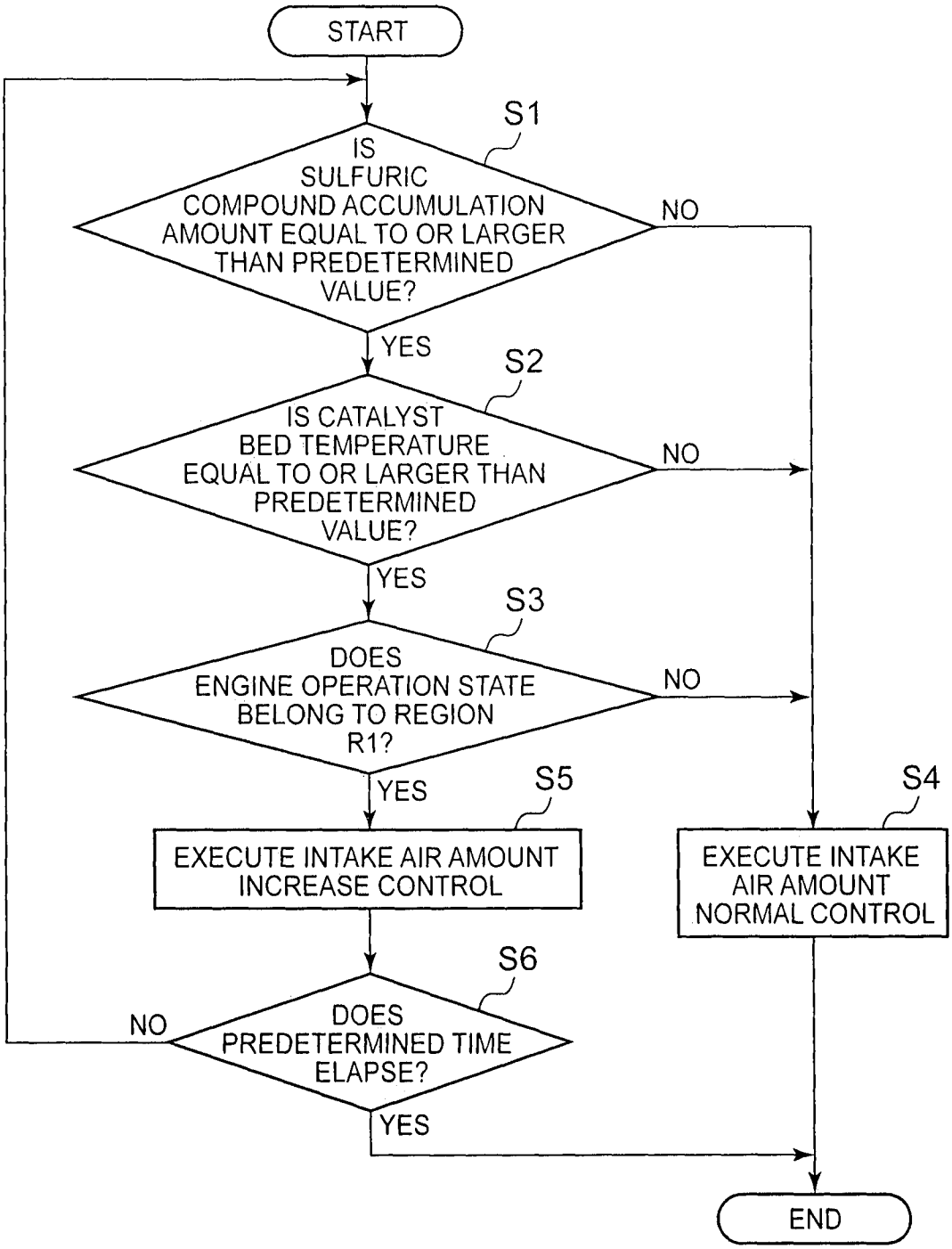


FIG. 4


START
S1
IS SULFURIC COMPOUND ACCUMULATION AMOUNT EQUAL TO OR LARGER THAN PREDETERMINED VALUE?
NO
YES
S2
IS CATALYST BED TEMPERATURE EQUAL TO OR LARGER THAN PREDETERMINED VALUE?
NO
YES
S3
DOES ENGINE OPERATION STATE BELONG TO REGION R1?
NO
YES
S5
EXECUTE INTAKE AIR AMOUNT INCREASE CONTROL
S4
EXECUTE INTAKE AIR AMOUNT NORMAL CONTROL
S6
DOES PREDETERMINED TIME ELAPSE?
NO
YES
END

INTERNATIONAL SEARCH REPORT

International application No
PCT/IB2015/000249

A. CLASSIFICATION OF SUBJECT MATTER
INV. F01N9/00 F01N3/10 F02D41/14 F02D41/00 F02D11/10
F02D41/02
ADD.
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
F01N F02D

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	DE 10 2009 058107 A1 (DAIMLER AG [DE]) 22 June 2011 (2011-06-22) paragraphs [0006] - [0012], [0018] - [0027]	1,2
A	WO 2012/126892 A1 (UMICORE AG & CO KG [DE]; NOACK HENDRIK-DAVID [DE]; SPURK PAUL [DE]; PF) 27 September 2012 (2012-09-27) page 1 - page 2	1-3
A	DE 101 53 901 A1 (VOLKSWAGEN AG [DE]) 24 April 2003 (2003-04-24) paragraph [0027] - paragraph [0041]; figure 4	1-5

-/--

[X] Further documents are listed in the continuation of Box C.

[X] See patent family annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
17 July 2015	10/08/2015

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Aign, Torsten

INTERNATIONAL SEARCH REPORT

International application No
PCT/IB2015/000249

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	WO 2006/017056 A1 (INT ENGINE INTELLECTUAL PROP [US]; WANG XINLEI [US]; BARASA PATRICK D) 16 February 2006 (2006-02-16) page 9 - page 11 page 16 - page 17 figures -----	1-5

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/IB2015/000249

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
DE 102009058107 A1	22-06-2011	NONE	
WO 2012126892 A1	27-09-2012	AR 085525 A1	09-10-2013
		DE 102011014718 A1	11-10-2012
		WO 2012126892 A1	27-09-2012
DE 10153901 A1	24-04-2003	NONE	
WO 2006017056 A1	16-02-2006	BR PI0511446 A	26-12-2007
		CA 2572853 A1	16-02-2006
		CN 1985077 A	20-06-2007
		EP 1766199 A1	28-03-2007
		JP 5329085 B2	30-10-2013
		JP 2008506066 A	28-02-2008
		KR 20070029288 A	13-03-2007
		US 2006086085 A1	27-04-2006
		WO 2006017056 A1	16-02-2006