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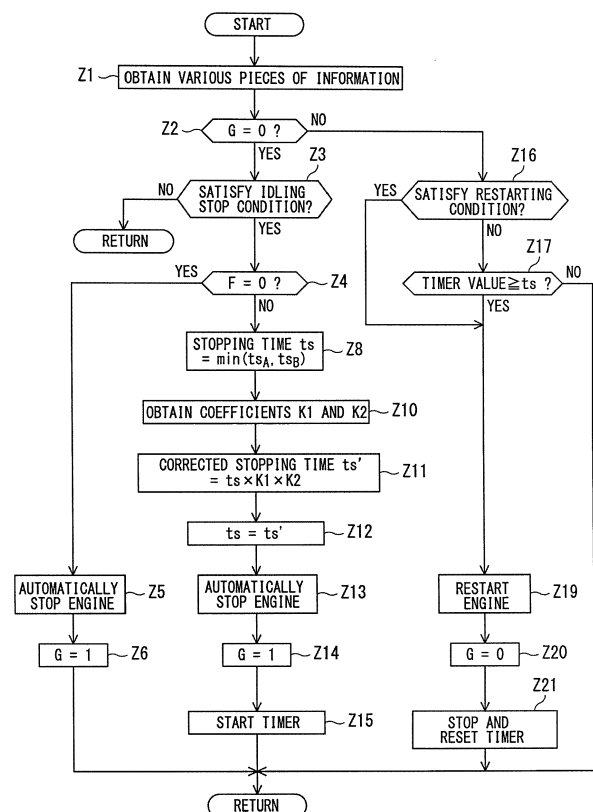
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(54) **CONTROLLER FOR INTERNAL COMBUSTION ENGINE**

(57) A controller (1) for an internal combustion engine (10) equipped with a processor (14B, 14C) that traps a predetermined substance contained in exhaust gas and processes the substance. The controller (1) includes: an estimator (2), a regeneration controller (3), a setter (5), and an idling stop controller (4). The estimator (2) estimates a trap amount (A, E) of the substance trapped by the processor (14B, 14C). The regeneration controller (3) carries out, when a predetermined regeneration condition is satisfied, regeneration control that removes the substance from the processor (14B, 14C). The setter (5) sets, when a predetermined idling stop condition is satisfied while the regeneration control is being carried out, a stopping time (t_s) of the internal combustion engine (10). The idling stop controller (4) stops the internal combustion engine (10) for the stopping time (t_s) from the time point at which the predetermined idling stop condition is satisfied.

FIG. 6



Description**FIELD**

5 **[0001]** The present invention relates to a controller for an internal combustion engine including a filter and a trap catalyst (hereinafter collectively referred to as "processors") that processes or treats substances contained in exhaust gas by trapping and storing the substance.

BACKGROUND

10 **[0002]** A conventional internal combustion engine is known for including processors of a filter that traps particulate matters (hereinafter referred to as "PMs") contained in exhaust gas and a trap catalyst that stores nitrogen oxides (NOx) and sulfur components (S) in the exhaust gas. These processors carry out control (hereinafter referred to as "regeneration control") that removes substances such as PMs and NOx temporarily contained in the processors through combustion, desorption, and reduction. During the regeneration control, the processors are heated to a temperature that allows the substances temporarily contained in the processors to be combusted, desorbed, and reduced.

15 **[0003]** Some vehicles with an engine has the idling stop function, which automatically halts and restarts the engine in accordance with a stop and start of the vehicle. Such a vehicle has an advantage of reducing the fuel consumption by means of idling stop, but has a disadvantage that in a case where idling stop is carried out during regeneration control, the regeneration control is interrupted and the temperature of the processors may be lowered. As a solution to the above, there is proposed a technique that: when an idling stop condition is satisfied, the temperature of the processors are confirmed; and when the temperature is high enough, the engine is automatically stopped to save the fuel consumption, whereas when the temperature is low, the automatic stop is prohibited to keep the temperature of the processors high (see, for example, Patent Literature 1 (pamphlet of WO 2011/070664)).

20 **[0004]** If the engine is automatically stopped during the regeneration control, additional fuel is added to the fuel injection amount after the restarting in order to compensate for the temperature decline of the processors during the idling stop. This additional fuel may excessively combust the substance trapped in the processors, and consequently, the temperature of the processor may excessively rise. In particular, when the amount of substances contained in the processors is large, the resultant increase in calorific value increases a possibility of an excessive rise in temperature of the processors; hence a possibility of melting or heat-deterioration of the processors is increased. Such an increase in calorific value can be further enhanced by sharp rise of oxygen concentration in the vicinity of the processors after restarting the engine regaining from the idling stop.

SUMMARY**TECHNICAL PROBLEMS**

35 **[0005]** With the foregoing problem in view, the object of the present invention is to provide an engine controller that is capable of inhibiting the temperature of the processor from excessively rising, while improving fuel consumption using a technique of idling stop. In addition to the above object, advantages being derived from the configurations to carry out the invention to be described below and not being achieved by traditional technique are considered as other objects.

SOLUTION TO PROBLEMS

45 **[0006]** (1) There is provided a controller that controls an internal combustion engine equipped with a processor that traps a predetermined substance contained in exhaust gas and processes the substance. The controller includes an estimator that estimates a trap amount of the substance trapped by the processor; a regeneration controller that carries out, when a predetermined regeneration condition is satisfied, regeneration control that removes the substance from the processor; a setter that sets, when a predetermined idling stop condition is satisfied while the regeneration control is being carried out, a stopping time of the internal combustion engine, the stopping time being based on the trap amount; and an idling stop controller that stops, when the stopping time is set, the internal combustion engine for the stopping time from the time point at which the predetermined idling stop condition is satisfied.

BRIEF DESCRIPTION OF DRAWINGS

55 **[0007]** The nature of this invention, as well as other objects and advantages thereof, will be explained in the following with reference to the accompanying drawings, in which like reference characters designate the same or similar parts throughout the figures and wherein:

FIG. 1 is a block diagram illustrating a controller according to an embodiment and schematically illustrating an engine to which the controller is applied;

FIG. 2A is an example of a map to obtain a stopping time based on a PM deposit amount; FIG. 2B is an example of a map to obtain a stopping time based on a PM combustion amount; FIG. 2C is an example of a map to obtain a stopping time based on a sulfur accumulation amount; and FIG. 2D is an example of a map to obtain a stopping time based on a sulfur removed amount;

FIG. 3A is an example of a map to obtain a coefficient to correct the stopping time on the basis of the exhaust gas temperature of the upstream side of a filter; and FIG. 3B is an example of a map to obtain a coefficient to correct the stopping time on the basis of the exhaust gas temperature of the downstream side of the filter;

FIG. 4 is an example of a map to obtain a coefficient to correct the stopping time on the basis of the intake air temperature;

FIG. 5 is a flow chart showing an example of a procedure of a filter regeneration control;

FIG. 6 is a flow chart showing an example of a procedure of an idling stop control;

FIGs. 7A-7D are time charts denoting the details of control; and

FIGs. 8A-8E are time charts denoting the details of control.

DESCRIPTION OF EMBODIMENTS

[0008] Description will now be made in relation to a controller for an internal combustion engine (hereinafter also referred to as an "engine") with reference to the accompanying drawings. The following embodiment is an example, so there is no intention to exclude application of various modifications and techniques not suggested in the following description to the embodiment. Various changes and modification can be suggested without departing from the gist of the embodiment. The accompanying drawings may include other elements and functions in addition to those in the drawings. Besides, the embodiment and the modification can be combined without contradiction in process to each other.

1. configuration of the device:

[0009] FIG. 1 is a diagram schematically illustrating an engine 10 and a controller 1 that controls the engine 10. The engine 10 of this embodiment is a diesel engine (compression ignition internal combustion engine) serving as a driving source of the vehicle and is mounted on, for example, an engine vehicle or a hybrid vehicle. The engine 10 has functions of idling stop, which automatically stops and restarts the engine 10 in line with the stopping and starting (departure) of the vehicle. The cylinder head of the engine 10 includes an injector 11 that injects fuel into the cylinder. An exhaust gas purification device 14 is disposed on an exhaust passage 13 of the engine 10.

[0010] The exhaust gas purification device 14 is a system that purifies exhaust gas by removing noxious substances contained in the exhaust gas, and for this purpose, includes an oxidizing catalyst 14A, a filter 14B, and a trap catalyst 14C.

[0011] The oxidizing catalyst 14A is a processor that can oxidize components in exhaust gas and is formed of a honeycomb carrier supporting a catalyst material. The oxidizing catalyst 14A has a function of purifying exhaust gas by trapping and oxidizing components exemplified by nitrogen monoxide (NO), hydrocarbon (HC), and carbon monoxide (CO) and a function of raising the exhaust gas temperature using the oxidation heat generated through the oxidation.

[0012] The filter 14B is a porous filter (processor) that traps PMs contained in exhaust gas and purifies the exhaust gas by filtering and trapping PMs contained in the exhaust gas passing inside the filter 14B. The filter 14B is also referred to as a Diesel Particulate Filter (DPF). PMs trapped and deposited (accumulated) in the filter 14B is combusted and removed while the vehicle is normally running and is combusted and removed also by forcibly raising the temperature of the filter 14B. The former removal of PMs is a method in which PMs are combusted on the filter 14B by mainly causing nitrogen dioxide (NO₂) contained in exhaust gas to act as an oxidizing agent (continuous regeneration method), whereas the latter removal of PMs is a method in which PMs are combusted on the filter 14B by mainly causing oxygen (O₂) to act as an oxidizing agent (forced regeneration method). Hereinafter, control of combusting PMs in the latter method is referred to as "filter regeneration control" and an amount (trapped amount) of PMs deposited in the filter 14B is referred to as "PM deposit amount A". An amount (removed amount) of PMs removed (combusted) since the filter regeneration control has started is referred to as a "PM combustion amount B", and a PM deposit amount A at the start of the filter regeneration control is referred to as an "initial deposit amount A_{START}".

[0013] When the engine 10 is operating and the filter regeneration control is not being carried out, the PM deposit amount A gradually increases. On the other hand, while the filter regeneration control is being carried out, the PM deposit amount A gradually decreases from the initial deposit amount A_{START}. In response to this reduction of the PM deposit amount A, the PM combustion amount B gradually increases from zero. This means that the PM deposit amount A during the filter regeneration control corresponds to a value obtained by subtracting the PM combustion amount B from the initial deposit amount A_{START}. It should be noted that, since the starting condition of the filter regeneration condition includes factors other than the PM deposit amount A, the initial deposit amount A_{START} does not necessarily be a constant

value. In other words, the initial deposit amount A_{START} is a variable value that varies in accordance with the operating state of the engine 10.

[0014] The trap catalyst 14C (processor) is a processor that purifies exhaust gas by trapping nitrogen oxide (NOx) contained in the exhaust gas, and is formed of a reduction catalyst whose surface supports occlusion material. The occlusion material has a function to store (occlude) NOx, being in the form of nitride, in exhaust gas under the oxidization atmosphere and release stored NOx (nitride) under the reduction atmosphere. NOx released from the trap catalyst 14C is reduced to give nitrogen (N_2) or ammonia (NH_3) by the reduction catalyst. Hereinafter, a control that releases NOx from the trap catalyst 14C and reduces the NOx to give N_2 is referred to as "NOx purge control".

[0015] In addition to NOx, sulfur components (S) contained in exhaust gas sometimes accumulates on the occlusion material of the trap catalyst 14C. Since only a small amount of the accumulating sulfur components (sulfur components in accumulating sulfur compound) is released during the NOx purge control, the amount of accumulating sulfur components gradually increases, thereby degrading the primary function (NOx trapping function) of the trap catalyst 14C. For the above, if a large amount of sulfur components accumulates, a control to release the accumulating sulfur components from the trap catalyst 14C is carried out. Hereinafter, the control is referred to as "sulfur purge control" and an amount (trapped amount) of sulfur components accumulating on the trap catalyst 14C is referred to as a "sulfur accumulation amount E". The removed amount of sulfur components removed since the sulfur purge control has started is referred to as a "sulfur removed amount R". The above filter regeneration control and the sulfur purge control are collectively referred to as "regeneration control".

[0016] On an intake air passage 12 of the engine 10, an intake air temperature sensor 20 that measures (detects) the temperature (intake air temperature T_{IN}) of intake air passing through the intake air passage 12 is disposed. Three exhaust gas temperature sensors 21, 22, 23, an air-fuel ratio sensor 24, and a differential pressure sensor 25 are disposed on the exhaust passage 13. The exhaust gas temperature sensors 21, 22 and 23 measure the temperature of exhaust gas. The air-fuel ratio sensor 24 measures an air-fuel ratio of exhaust gas. The differential pressure sensor 25 measures the differential pressure P between pressures on upstream and downstream of the filter 14B. The exhaust gas temperature sensor 21 disposed between the oxidizing catalyst 14A and the filter 14B and measures the temperature (hereinafter "upstream temperature T_F ") at the upstream side of the filter 14B. The exhaust gas temperature sensor 22 is disposed immediately downstream of the filter 14B and measures the temperature (hereinafter "downstream temperature T_R ") at the downstream side of the filter 14B. The exhaust gas temperature sensor 23 is disposed immediately upstream of the trap catalyst 14C and measures the temperature (hereinafter "most downstream temperature T_C ") at the upstream side of the trap catalyst 14C. Pieces of information measured by the sensors 20-25 are sent to the controller 1.

[0017] The controller 1 is a computer that controls the entirety of the engine 10 and is connected to a communication line of the on-board network. The controller 1 is an electronic device (Electronic Control Unit; ECU) integrating, for example, a microprocessor such as a Central Processing Unit (CPU) and a Micro Processing Unit (MPU), a Read Only Memory (ROM), a Random Access Memory (RAM), and a non-volatile memory. A processor here includes therein, for example, a control unit (control circuit), a calculation unit (calculation circuit), and a cache memory (register). A ROM, a RAM, and a non-volatile memory are memory devices in which programs and data being processed are stored. The contents of control to be carried out by the controller 1 is stored, being in the form of the firmware and application programs, in the ROM, the RAM, the non-volatile memory, or a removable medium. In executing a program, the contents of the program is expanded in the memory space of the RAM and is carried out by the processor.

2. control configuration:

[0018] The controller 1 has a function (idling stop control function) that controls automatic stopping and restarting of the engine 10. Specifically, the controller 1 stops, when a predetermined idling stop condition is satisfied, fuel injection from the injector 11 to automatically stop the engine 10, and restarts, when a predetermined restarting condition is satisfied, the engine 10.

[0019] In addition, the controller 1 has a function to carry out the above filter regeneration control and the sulfur purge control, both of which aim at recovering the purification performance of the exhaust gas purification device 14. Here, the NOx purge control also aims at recovering the purification performance of the exhaust gas purification device 14, but is excluded from the "regeneration control" of this embodiment. In the filter regeneration control, a predetermined amount of fuel is post-injected from the injector 11 to raise the temperature of the filter 14B to a temperature equal to or higher than the combustion temperature of the PMs. In the sulfur purge control, a predetermined amount of fuel is post-injected from the injector 11 to make the ambient atmosphere of the trap catalyst 14C to a reduction atmosphere and raise the temperature of the trap catalyst 14C to a temperature equal to or higher than a temperature at which the trap catalyst 14C releases sulfur components.

[0020] As the elements to achieve the above functions, the controller 1 includes an estimator 2, a regeneration controller 3, an idling stop controller 4, and a setter 5. These elements are part of the functions of the program to be carried out by the controller 1 and assumed by means of software. Alternatively, part or the entire of each functions may be achieved

by hardware (electronic control circuit) or in combination of software and hardware.

2-1. Estimator:

[0021] The estimator 2 estimates the PM deposit amount A, the PM combustion amount B, the sulfur accumulation amount E, and the sulfur removed amount R. Various known methods can be applied to estimating these amounts. For example, the PM deposit amount A may be estimated by periodically estimating an amount of PMs exhausted from the engine 10 on the basis of the engine speed, the engine load of the engine 10, etc. and accumulating the estimated amounts from the end of the previous filter regeneration control. For example, the PM deposit amount A may also be estimated on the basis of the differential pressure between pressures on upstream and downstream of the filter 14B. The PM combustion amount B may be estimated on the basis of an executing time of the filter regeneration control, a temperature of the exhaust gas (upstream temperature T_F , downstream temperature T_R), and/or a flow amount of the exhaust gas, or on the basis of a change in the differential pressure between pressures on upstream and downstream of the filter 14B.

[0022] The estimator 2 estimates the PM combustion amount B using a parameter different from a parameter used to estimate the PM deposit amount A. The estimator 2 of this embodiment estimates the PM deposit amount A on the basis of the differential pressure P detected by the differential pressure sensor 25 while the engine 10 is operating. While the engine 10 is operating and the filter regeneration control is also being carried out, the estimator 2 estimates the PM combustion amount B on the basis of a parameter other than the differential pressure P. This means that the PM combustion amount B is not estimated (calculated) on the basis of the PM deposit amount A, but these PM amounts A and B are independently (separately) estimated. For this reason, a value ($A_{START}-B$) obtained by subtracting the PM combustion amount B estimated at a predetermined time point from the PM deposit amount A (i.e., the initial deposit amount A_{START}) estimated at the start of the filter regeneration control does not always match the PM deposit amount A estimated at the same time point.

[0023] The sulfur accumulation amount E is estimated by accumulating an amount of fuel used from the end of the previous sulfur purge control and multiplying the accumulated amount of used fuel by a coefficient according to the kind of fuel. The estimator 2 estimates the sulfur accumulation amount E using these parameters while the engine 10 is operating. When the sulfur purge control is not being carried out, the sulfur accumulation amount E increases with an amount of used fuel. On the other hand, while the sulfur purge control is being carried out, the sulfur accumulation amount E is gradually reduced because sulfur components accumulated on the trap catalyst 14C is desorbed and reduced. Therefore, the sulfur removed amount R that is an amount of sulfur components released during the sulfur purge control is estimated on the basis of, for example, the sulfur accumulated amount E, the air-fuel ratio, the temperature, or the flow amount of exhaust gas. The estimator 2 transmits the regeneration controller 3 of the results of the estimation.

2-2. regeneration controller:

[0024] The regeneration controller 3 carries out the regeneration control of the exhaust gas purification device 14 (i.e., the filter regeneration control and the sulfur purge control) when a predetermined regeneration condition is satisfied. An example of the predetermined regeneration condition is one satisfied when the PM deposit amount A and/or the sulfur accumulation amount E of the filter 14B need to be forcibly removed. In this example, the regeneration controls have respective starting conditions and finishing conditions, which are independently of each other determined, and are independently of each other carried out. The starting conditions and the finishing conditions are appropriately set on the basis of, for example, the degree of pressure drop of the filter 14B, the erosion risk of the filter 14B due to excessive deposition of PMs, and/or the degree of degrading the function of the trap catalyst 14C due to accumulation of sulfur components. Alternatively, the PM deposition amount A and the sulfur accumulation amount E estimated by the estimator 2 may be included in the starting condition, and the PM deposition amount A, the PM combustion amount B, the sulfur accumulation amount E and the sulfur removed amount R estimated by the estimator 2 may be included in the finishing condition. These two regeneration controls can be carried out in parallel with each other (simultaneously).

2-3. idling stop controller:

[0025] The idling stop controller 4 controls the idling stop of the engine 10. The idling stop controller 4 carries out a control that automatically stops (stops idling) the engine 10 when an idling stop condition is satisfied while the engine 10 is operating. The idling stop condition is satisfied when the engine 10 can be stopped from the viewpoint of reducing the fuel consumption and is exemplified by the vehicle being stopped and the brake being on. When a restarting condition is satisfied while the engine 10 is automatically stopped, the idling stop controller 4 carries out a control that restarts the engine 10. An example of the restarting condition is the brake being off. If either regeneration control is being carried out at a time point when the idling stop condition is satisfied, the idling stop controller 4 carries out a control that restarts

the engine 10 when a stopping time t_s has expired after the satisfaction of the idling stop condition. This restarting of the engine 10 is carried out even if the restarting condition is not satisfied. The stopping time t_s is set to be in the range of equal to or more than zero second.

[0026] This execution time of the idling stop during the regeneration control is set to be shorter than that in a case where the regeneration control is not carried out. In other words, if the regeneration control is being carried out at the start of the idling stop, the execution time of the idling stop is at least shortened, and occasionally, the idling stop is prohibited. This suppresses temperature decline of the filter 14B and the trap catalyst 14C and also suppresses excessive temperature rise of the filter 14B and the trap catalyst 14C due to the post-injection after restarting the engine 10.

[0027] When determining that "the idling stop condition is satisfied", the idling stop controller 4 transmits the setter 5 of the result of the determination. When determining that "the restarting condition is satisfied", the idling stop controller 4 transmits the setter 5 of the result of the determination. These conditions are appropriately set.

2-4. setter:

[0028] When the idling stop condition is satisfied while the regeneration control is being carried out, the setter 5 sets the stopping time t_s of the engine 10 on the basis of a trapped amount (the PM deposit amount A and the sulfur accumulation amount E) estimated by the estimator 2 at the time point when the idling stop condition is satisfied. The stopping time t_s set by the setter 5 corresponds to the longest time (idling stop time) during which the idling stop state can be maintained. In other words, if the engine 10 is being automatically stopped at the time point when the stopping time t_s has expired after the satisfaction of the idling stop condition, the engine 10 is restarted even if the restarting condition is not satisfied yet. During the automatic stop of the engine 10, all regeneration controls are interrupted.

[0029] The setter 5 sets the stopping time t_s using a parameter according to the type of regeneration control being carried out at a time point when the idling stop condition is satisfied and transmits the idling stop controller 4 of the set stopping time t_s . For example, when the filter regeneration control is being carried out, the setter 5 sets the stopping time t_s on the basis of the PM deposit amount A and/or the PM combustion amount B; when the sulfur purge control is being carried out, the setter 5 sets the stopping time t_s on the basis of the sulfur accumulation amount E and/or the sulfur removed amount R.

[0030] Hereinafter, description will now be made in relation to the three setting methods of setting the stopping time t_s in the filter regeneration control.

[0031] The first setting method sets the stopping time t_s based only on the PM deposit amount A. The second setting method sets the stopping time t_s based on both the PM deposit amount A and PM combustion amount B. The third setting method sets the stopping time t_s using the first or second setting method and then corrects the set stopping time t_s using the exhaust gas temperature in the vicinity of the filter 14B. Although the stopping time t_s can be set in any one of the first to third setting method, the second setting method is adopted when the filter regeneration control is started due to the PM deposit amount A (e.g., because the PM deposit amount A is large), and the third setting method is adopted when the filter regeneration control is started regardless of the PM deposit amount A (e.g. under the state where the PM deposit amount A is small) in this embodiment.

[0032] In the first setting method, the stopping time t_s is set to be longer as the PM deposit amount A when the idling stop condition is satisfied is smaller. This aims at improving fuel consumption by setting the stopping time t_s to be longer because a smaller PM deposit amount A has a lower possibility of excessively raising the temperature of the filter 14B after restarting the engine 10 regaining from automatically stop. The setter 5 sets the stopping time t_s using, for example, a map or a calculation expression that defines the relationship between the PM deposit amount A and the stopping time t_s . The map or calculation expression is stored in the controller 1 in advance.

[0033] When the PM deposit amount A exceeds a first threshold A1, the setter 5 sets the stopping time t_s to zero; and when the PM deposit amount A is equal to or less than the first threshold A1, the setter 5 sets the stopping time t_s to be in the range equal to or more than a minimum time t_{so} . The first threshold A1 is a value previously set in consideration of the relationship between the amount of PMs deposited on the filter 14B and the possibility of excessively raising the temperature of the filter 14B. When the PM deposit amount A is larger than the first threshold A1, the setter 5 sets the stopping time t_s to zero by giving avoiding excessively raising the temperature a higher priority than improving the fuel consumption. In this case, the engine 10 is not automatically stopped even if the idling stop condition is satisfied (i.e., the engine 10 is kept to operating).

[0034] The minimum time t_{so} is previously set to be a value (e.g., about 10 seconds) that does not make the passenger feel uncomfortable due to idling stop. The engine 10 restarts without an operation by the passenger if the engine 10 does not restart until the stopping time t_s since the automatic stop of the engine 10 expires. For this reason, the passenger may feel uncomfortable if a time (i.e., stopping time t_s) between automatic stopping and restarting of the engine 10 is too short. As a solution to the above, since the setter 5 of this embodiment sets the stopping time t_s to be equal to or longer than the minimum time t_{so} when the PM deposit amount A is equal to or less than the first threshold A1, this setting less makes the passenger feel uncomfortable.

[0035] FIG. 2A is an example of a map used by the setter 5. This map defines the relationship between the PM deposit amount A and the stopping time t_s and includes a solid-line graph and a one-dotted-line graph. The two graphs are different in deviation manner of the stopping time t_s when the PM deposit amount A is smaller than the first threshold A1. Specifically, the solid-line graph is set such that the stopping time t_s comes to be stepwisely longer as the PM deposit amount A is smaller while the one-dotted-line graph is set such that the stopping time t_s comes to be longer gradually (at a constant gradient) as the PM deposit amount A is smaller. Both graphs set the stopping time t_s to zero when the PM deposit amount A is larger than the first threshold A1 and to be the minimum time t_{s0} when the PM deposit amount A is equal to the first threshold A1.

[0036] In the second setting method, the stopping time t_s is set to be longer as the PM deposit amount A when the idling stop condition is satisfied is smaller and also the PM combustion amount B when the idling stop condition is satisfied is larger. Since the PM deposit amount A and the PM combustion amount B are estimated on the basis of respective different parameters, setting the stopping time t_s using the two PM amounts A and B further inhibits excessive rise of the temperature of the filter 14B. Accordingly, even if two PM amounts A and B each have an error between the estimated value and the actual value, it is possible to inhibit excessive rise of the temperature after the restarting by, for example, weighing the two PM amounts A and B or by preferentially using one of the two PM amounts A and B that can reduce the possibility of excessively raising the temperature.

[0037] As a specific method of setting the stopping time t_s considering the PM combustion amount B in addition to the PM deposit amount A, preliminary storing a three-dimensional map or a calculation expression that defines the relationship among the PM deposit amount A, the PM combustion amount B, and the stopping time t_s in the memory devices can be exemplified. Alternatively, a map defining the relationship between the PM combustion amount B and the stopping time (second stopping time t_{sB}) in addition to the map of FIG. 2A may be preliminarily stored in the memory devices. An example of this alternative map is denoted in FIG. 2B.

[0038] The map of FIG. 2B defines the relationship between the PM combustion amount B and the stopping time (second stopping time t_{sB}) and includes a solid-line graph and a one-dotted-line graph. The two graphs are different in deviation manner of the second stopping time t_{sB} when the PM combustion amount B is in the range equal to or more than a second threshold B1. Specifically, the solid-line graph is set such that the second stopping time t_{sB} comes to be stepwisely longer as the PM combustion amount B is larger while the one-dotted-line graph is set such that the second stopping time t_{sB} comes to be longer gradually (at a constant gradient) as the PM combustion amount B is larger. Both graphs set the second stopping time t_{sB} to zero when the PM combustion amount B is smaller than the second threshold B1 and to be the minimum time t_{s0} when the PM combustion amount B is equal to the second threshold B1.

[0039] In this case, the setter 5 uses the value obtained from the map of FIG. 2A on the basis of the PM deposit amount A and the value obtained from the map of FIG. 2B on the basis of the PM combustion amount B as a first stopping time t_{sA} and the second stopping time t_{sB} , respectively. Then the setter 5 sets a safer stopping time (having a lower possibility of excessively raising the temperature) by selecting a shorter one of the first stopping time t_{sA} and the second stopping time t_{sB} as the stopping time t_s , so that the protectability of the filter 14B can be enhanced.

[0040] In the third setting method, the stopping time t_s is set in the first or second setting method as the reference, and then the set stopping time t_s is corrected to a smaller value as the exhaust gas temperature in the vicinity of the filter 14B is lower. This means that, when the temperature of at least one of the upstream side and the downstream side of the filter 14B (i.e., at least one of the upstream temperature T_F and the downstream temperature T_R when the idling stop condition is satisfied) is relatively low, the setter 5 corrects the set stopping time t_s on the basis of the exhaust gas temperature. In this case, the setter 5 sets the corrected stopping time $t_{s'}$ as a new stopping time t_s and transmits the idling stop controller 4 of the new stopping time t_s .

[0041] The setter 5 may use both the upstream temperature T_F and the downstream temperature T_R to correct the stopping time t_s . Specifically, the setter 5 obtains two coefficients K1 and K2 from maps denoted in FIGs. 3A and 3B and corrects the stopping time t_s using the following expression 1. The coefficients K1 and K2 are used to correct the stopping time t_s and are each a value equal to or more than zero and equal to or less than one ($0 \leq K1 \leq 1$, $0 \leq K2 \leq 1$).

$$\text{corrected stopping time } t_{s'} = t_s \times K1 \times K2 \quad (\text{expression 1})$$

[0042] FIG. 3A is an example of a map defining the relationship between the upstream temperature T_F and the first coefficient K1 and FIG. 3B is an example of a map defining the relationship between the downstream temperature T_R and the second coefficient K2. These maps are stored in the controller 1 beforehand. The first coefficient K1 is set to one when the upstream temperature T_F is equal to or higher than a first upstream temperature T_{F1} (first temperature) and is set to zero when the upstream temperature T_F is equal to or lower than a second upstream temperature T_{F2} (second temperature). When the upstream temperature T_F is higher than the second upstream temperature T_{F2} and is lower than the first upstream temperature T_{F1} , the first coefficient K1 is set so as to increase at a constant gradient.

[0043] The second coefficient K_2 is set to one when the downstream temperature T_R is equal to or higher than a first downstream temperature T_{R1} (first temperature) and is set to zero when the downstream temperature T_R is equal to or lower than a second downstream temperature T_{R2} (second temperature). When the downstream temperature T_R is higher than the second downstream temperature T_{R2} and is lower than the first downstream temperature T_{R1} , the second coefficient K_2 is set so as to increase at a constant gradient. The first upstream temperature T_{F1} and the first downstream temperature T_{R1} are set to be temperatures at which the PMs on the filter 14B starts combusting, for example. The second upstream temperature T_{F2} and the second downstream temperature T_{R2} are lower than the first upstream temperature T_{F1} and the first downstream temperature T_{R1} , respectively, and are set to be sufficiently lower than the temperatures at which the PMs on the filter 14B starts combusting, for example. The two first temperatures T_{F1} and T_{R1} may be set to be the same as each other or different from each other; and likewise the two second temperatures T_{F2} and T_{R2} may be set to be the same as each other or different from each other. For example, since the temperature of exhaust gas at the upstream side of the filter 14B tends to more easily rise than that at the downstream side, the first temperatures may be set to be $T_{F1} > T_{R1}$ so that the stopping time t_s can be easily corrected.

[0044] Accordingly, when the exhaust gas temperatures T_F and T_R are equal to or lower than the first temperatures T_{F1} and T_{R1} , respectively, in other words, when the upstream temperature T_F is equal to or lower than the first upstream temperature T_{F1} or the downstream temperature T_R is equal to or lower than the first downstream temperature T_{R1} , the setter 5 corrects the stopping time t_s to be more shortened as the exhaust gas temperatures T_F and T_R are lower. When the exhaust gas temperatures T_F and T_R are equal to or lower than the second temperatures T_{F2} and T_{R2} , respectively, in other words, when the upstream temperature T_F is equal to or lower than the second upstream temperature T_{F2} or the downstream temperature T_R is equal to or lower than the second downstream temperature T_{R2} , the setter 5 corrects the stopping time t_s to zero. This prohibits idling stop, and therefore the temperatures of the filter 14B and the trap catalyst 14C rapidly rise.

[0045] When the exhaust gas temperatures T_F and T_R are higher than the first temperatures T_{F1} and T_{R1} , respectively, the set stopping time t_s is not changed because the coefficients K_1 and K_2 are both one. Specifically, when the PMs on the filter 14B are combusting, the exhaust gas temperatures T_F and T_R are naturally higher than the first temperatures T_{F1} and T_{R1} , respectively, and therefore the coefficients K_1 and K_2 are both one, so that the correction on the stopping time t_s based on the exhaust gas temperatures T_F and T_R is not substantially carried out. Here, when the filter regeneration control is started under a state where the PM deposit amount A is equal to or larger than the first threshold A_1 , the stopping time t_s is set to zero. Therefore, even if the exhaust gas temperatures T_F and T_R are both low, the stopping time t_s is zero. This means that when the filter regeneration control is started under a state where the PM deposit amount A is equal to or larger than the first threshold A_1 or the PMs are already combusting, the stopping time t_s is kept to be the value set on the basis of, for example, the PM deposit amount A , not being affected by the correction using the exhaust gas temperatures T_F and T_R . In other words, the setter 5 corrects the stopping time t_s in accordance with the exhaust gas temperatures T_F and T_R at least when the filter regeneration control is started under a state where the PM deposit amount A is smaller than the first threshold A_1 .

3. flow chart:

3-1. filter regeneration control:

[0046] FIG. 5 is a flow chart illustrating an example of a control procedure of the filter regeneration control. This flow chart of steps is repeatedly carried out at a predetermined calculation period under a state, for example, where the ignition key switch (main switch) of the vehicle is on. A flag F used in this flow chart represents a state of executing the filter regeneration control and set to one ($F=1$) during the execution of the filter regeneration control. The estimation of the amounts such as the PM deposit amount A by the estimator 2 is assumed as being carried out independently of this flow chart.

[0047] At first, various pieces of information to be used for determination as to whether the filter regeneration control is to be carried out are obtained (step Y1). The information obtained in this step includes the PM deposit amount A estimated by the estimator 2. When the flag F is set to zero ($F=0$; step Y2), a determination is made as to whether the starting condition of the filter regeneration control is satisfied (step Y3). If the starting condition is satisfied, the flag F is set to one ($F=1$; step Y4) and the filter regeneration control is started (step Y7) to finish the control of this calculation period. In contrast, if the starting condition is not satisfied, the flag F is unchanged ($F=0$) and the control of this calculation period is finished.

[0048] During the execution of the filter regeneration control represented by the flag F being set to one ($F=1$), a determination is made as to whether the finishing condition of the filter regeneration control is satisfied (step Y8). If the finishing condition is not satisfied, the control of this calculation period is finished and the filter regeneration control is continued. On the other hand, when the finishing condition is satisfied, the filter regeneration control is finished (step Y9) and the flag F is set to zero ($F=0$; step Y10) to finish the control of this calculation period.

3-2. idling stop control:

[0049] FIG. 6 is a flow chart illustrating an example of a procedure of controlling automatic stopping and restarting of the engine 10 (i.e., idling stop control). This flow chart of steps is repeatedly carried out at a predetermined calculation period under a state, for example, where the ignition key switch (main switch) of the vehicle is on. This flow chart is carried out in parallel with the flow chart of FIG. 5 and uses the information of the flag F set in the course of the flow chart of FIG. 5. A flag G used in this flow chart represents a state of automatic stopping of the engine 10 and set to one ($G=1$) while the engine 10 is automatically stopped. The estimation of the amounts such as the PM deposit amount A by the estimator 2 is assumed as being carried out independently of this flow chart.

[0050] At first, various pieces of information to be used for determination as to whether the idling stop control is to be carried out are obtained (step Z1). The information obtained in this step includes the PM deposit amount A and the PM combustion amount B estimated by the estimator 2. If the flag G is zero ($G=0$; step Z2), a determination is made as to whether the idling stop condition is satisfied (step Z3). If the idling stop condition is satisfied, the procedure proceeds to step Z4, whereas if the idling stop condition is not satisfied, the control of this calculation period is finished and the state of operating the engine 10 is continued.

[0051] In step Z4, a determination is made as to whether the flag F is zero ($F=0$). Namely, a determination is made as to whether the filter regeneration control is being carried out. If the filter regeneration control is not being carried out (i.e., if $F=0$), the engine 10 is automatically stopped (step Z5) and also the flag G is set to one ($G=1$; step Z6) to finish the control of this calculation period. In contrast, if flag F is not zero, the first stopping time ts_A is obtained on the basis of the PM deposit amount A and the second stopping time ts_B is obtained on the basis of the PM combustion amount B and the smaller of the stopping times ts_A and ts_B is set to be the stopping time ts (step Z8; second setting method). The illustrated example adopts the second setting method, but may alternatively adopt the first setting method.

[0052] Next, the first coefficient K1 and the second coefficient K2 are obtained on the basis of the upstream temperature T_F and the downstream temperature T_R (step Z10), the stopping time ts set in step Z8 is corrected, and a new stopping time ts is set (steps Z11 and Z12, third setting method). In next step Z13, the engine 10 is automatically stopped and the flag G is set to one ($G=1$; step Z14), and the timer is started (step Z15) to finish the control of this calculation period. The timer counts the automatic stopping time.

[0053] Since the flag G is set to one ($G=1$) while the engine 10 is automatically stopped, the process moves from step Z2 to step Z16. In step Z16, a determination is made as to whether the restarting condition is satisfied, and if the restarting condition is satisfied, the engine 10 is restarted (step Z19). In contrast, if the restarting condition is not satisfied, a determination is further made as to whether the value counted by the timer is equal to or longer than the stopping time ts set in step Z12 (step Z17). In other words, a determination is made as to whether a time elapsed since the engine 10 is automatically stopped is equal to or longer than the stopping time ts , and if the elapsed time is equal to or longer than the stopping time ts , the engine 10 is restarted (step Z19).

[0054] If the timer value is not equal to or longer than the stopping time ts , the control of this calculation period is finished, keeping the engine 10 to be automatically stopped. In contrast, if the engine 10 is restarted in step Z19, the flag G is set to zero ($G=0$; step Z20). If the timer is counting the time in step Z19, the counting is stopped and reset (step Z21) to finish the control of this calculation period.

4. operation:

[0055] Description will now be made in relation to the filter regeneration control with reference to FIGs. 7 and 8. FIGs. 7A-7D are time charts when the filter regeneration control is started under a state where the PM deposit amount A is equal to or larger than the first threshold A1, that is, a state having a high possibility of excessively raising the temperature of the filter 14B; and FIGs. 8A-8E are time charts when the filter regeneration control is started under a state where the PM deposit amount A is smaller than the first threshold A1, that is, a state having a low possibility of excessively raising the temperature of the filter 14B.

[0056] As shown in FIG. 7A, the filter regeneration control is started at the time t_0 , and if the idling stop condition is satisfied at the time t_1 , the first stopping time ts_A and the second stopping time ts_B are obtained on the basis of the PM deposit amount A and the PM combustion amount B at the time t_1 , respectively. As shown in FIG. 7C, the PM deposit amount A is larger than the first threshold A1 and the PM combustion amount B is less than the second threshold B1 at the time t_1 ; hence the first stopping time ts_A and the second stopping time ts_B are both zero and the stopping time ts is set to zero ($ts=0$). For the above, as shown in FIG. 7B, idling stop is prohibited at the time t_1 and a predetermined idling engine speed Neo is maintained.

[0057] As shown in FIGs. 7C and 7D, when the filter temperature rose, PMs start combusting on the filter 14B to reduce the PM deposit amount A, increasing the PM combustion amount B. When the idling stop condition is satisfied again at the time t_3 , since the PM deposit amount A is smaller than the first threshold A1 and the PM combustion amount B is larger than the second threshold B1 at the time t_3 , values equal to or more than the minimum time ts_0 are obtained

to be the first stopping time ts_A and the second stopping time ts_B . The shorter one of the first stopping time ts_A and the second stopping time ts_B is set to be the stopping time ts .

[0058] Accordingly, the engine 10 is automatically stopped at the time t_3 and is kept to be in the state of idling stop until the stopping time ts since the time t_3 expires. This reduces the fuel consumption amount. If the restarting condition is not satisfied during the stopping time ts since the time t_3 , the engine 10 is restarted at the time t_4 when the stopping time ts expires. This suppresses the amount of lowering the filter temperature during the automatic stopping and consequently reduces the amount of post-injection required after the restarting, so that the temperature of the filter 14B after the restarting is prevented from excessively rising.

[0059] If the idling stop condition is satisfied again at the time t_6 at the final phase of the filter regeneration control, the stopping time ts set at the time t_6 is relatively long. For the above, the engine 10 is automatically stopped at the time t_6 and, for example, if the restarting condition is satisfied at the time t_7 before the stopping time ts expires, the engine 10 is restarted at the time t_7 . This can enjoy the benefit of fuel consumption saving from idling stop.

[0060] As illustrated in FIG. 8C, description will now be made in relation to a case where the filter regeneration control is started at the time t_{10} when the PM deposit amount A is less than the first threshold $A1$. As illustrated in FIG. 8A, if the idling stop condition is satisfied at the time t_{11} , the stopping time ts is set on the basis of the PM deposit amount A at the time t_{11} and the coefficients $K1$ and $K2$ are obtained on the basis of the upstream temperature T_F and the downstream temperature T_R , respectively. As shown in FIGs. 8D and 8E, the exhaust gas temperatures T_F and T_R rise from the upstream side. Since the downstream temperature T_R is lower than the second downstream temperature T_{R2} , the second coefficient $K2$ is set to zero; hence the set stopping time ts is corrected to zero. Therefore, as shown in FIG. 8B, the idling stop is prohibited at the time t_{11} and the predetermined idling engine speed Neo is maintained.

[0061] If the idling stop condition is satisfied again at the time t_{13} , the stopping time ts is set on the basis of the PM deposit amount A at the time t_{13} . Since PMs do not start combusting yet at the time t_{13} , the stopping time ts is set to be the same as the one set at the time t_{11} . On the other hand, since the upstream temperature T_F is higher than the first upstream temperature T_{F1} at the time t_{13} , the first coefficient $K1$ is set to one, whereas since the downstream temperature T_R is higher than the second downstream temperature T_{R2} , the second coefficient $K2$ is set to a value larger than zero. This means that the corrected stopping time ts' is not zero but is smaller by the second coefficient $K2$ than the stopping time ts set at the time t_{11} , and is consequently set to be the new stopping time ts .

[0062] Accordingly, the engine 10 is automatically stopped at the time t_{13} and is kept to be in the state of idling stop until the stopping time ts expires since the time t_{13} . This reduces the fuel consumption amount. If the restarting condition is not satisfied during the stopping time ts since the time t_{13} , the engine 10 is restarted at the time t_{14} when the stopping time ts expires. This suppresses the degree of lowering the filter temperature during the automatically stopping, so that the temperature of the filter 14B is enhanced to rise.

[0063] If the idling stop condition is satisfied again at the time t_{16} at which the downstream temperature T_R exceeds the first downstream temperature T_{R1} , the both coefficients $K1$ and $K2$ are one at the time t_{16} , so that the stopping time ts set on the basis of the PM deposit amount A is maintained without being corrected. Accordingly, the engine 10 is automatically stopped at the time t_{16} , and if the restarting condition is satisfied at the time t_{17} before the stopping time ts expires, the engine 10 is restarted at the time t_{17} . This can enjoy the benefit of fuel consumption saving from idling stop.

5. effect:

[0064]

(1) In the above controller 1, if the idling stop condition is satisfied during the execution of the regeneration control, the stopping time ts is set on the basis of the trapped amount (i.e., the PM deposit amount A) and the engine 10 is automatically stopped for the stopping time ts since the satisfaction of the idling stop condition. Because the possibility of excessively raising the temperature of the processors such as the filter 14B and the trap catalyst 14C after the restarting from the idling stop tends to be higher as the trapped amount is larger, the risk of excessive temperature rise can be avoided by setting the stopping time ts on the basis of the trapped amount. Accordingly, it is possible to inhibit the temperature of the processors from excessively rising after the restarting, improving the fuel consumption by means of idling stop.

(2) As shown in FIG. 2A, for example, the above controller 1 sets the stopping time ts to be longer as the trapped amount is smaller because a smaller trapped amount causes the substance to less emit heat after the restarting and therefore the processors have a less risk to excessively raising the temperature thereof. Setting a longer stopping time ts as the trapped amount is smaller makes it possible to inhibit excessively raising the temperature, improving fuel consumption.

(3) In the above controller 1, when the trapped amount (PM deposit amount A) exceeds the first threshold $A1$, the stopping time ts is set to zero. In other words, if the amount of substance trapped by the processor is large, idling stop is prohibited even when the idling stop condition is satisfied and consequently the engine 10 is kept in the state

of operating. This can prevent the temperature of the processor from excessively rising after the restarting.

(4) In the above controller 1, when the trapped amount (PM deposit amount A) is equal to or smaller than the first threshold A1, the stopping time t_s is set to be equal to or longer than the minimum time t_{s0} . In other words, when the idling stop control is to be carried out, the minimum time t_{s0} is ensured for idling stop until the engine 10 restarts if the driver makes no action. For the above, it is possible to avoid the circumstance where the engine 10 restarts immediately after the start of the idling stop, and therefore it becomes possible to prevent the passenger from feeling uncomfortable.

(5) In the above controller 1, the shorter one of the first stopping time t_{sA} and the second stopping time t_{sB} obtained on the basis of the PM deposit amount A and the PM combustion amount B, respectively, is set to be the stopping time t_s . Advantageously, it is possible to set a safer stopping time (having a lower possibility of excessively raising the temperature) in consideration of estimation error by estimating the PM combustion amount B in addition to the PM deposit amount A and setting the final stopping time t_s based on respective PM amounts A and B, so that the protectability of the filter 14B can be further enhanced.

(6) In the above controller 1, if the exhaust gas temperatures T_F and T_R are equal to or lower than the first temperatures T_{F1} and T_{R1} , respectively, the stopping time t_s is corrected to a smaller value as the exhaust gas temperatures T_F and T_R are lower. In other words, if the exhaust gas temperatures T_F and T_R do not increase to the first temperatures T_{F1} and T_{R1} , the stopping time t_s set on the basis of the trapped amount is corrected to a smaller value. This correction is made because there is little possibility of excessively raising the temperature of the processors and it is rather preferred to rapidly raise the temperature of the processors so that the regeneration control can be enhanced. Namely, if the exhaust gas temperatures T_F and T_R are equal or lower than the first temperatures T_{F1} and T_{R1} , respectively, setting the stopping time t_s of the engine 10 to be shorter can enhance the temperature rise of the processors and consequently reduces the time for the regeneration. This can reduce the amount of fuel consumed by the regeneration control.

(7) In the above controller 1, if the exhaust gas temperatures T_F and T_R are equal to or lower than the second temperatures T_{F2} and T_{R2} , respectively, the stopping time t_s is corrected to zero and thereby the temperature rise of the processors are enhanced. Consequently, this reduces the time for the regeneration and also reduces the amount of fuel consumed by the regeneration control.

[0065] In the above embodiment, the upstream temperature T_F and the downstream temperature T_R of the filter 14B are used as the exhaust gas temperature and the coefficients K1 and K2 corresponding to the respective temperatures T_F and T_R are obtained. Using these obtained coefficients K1 and K2, the stopping time t_s is corrected. Since the filter 14B is a device having a relatively large heat capacity, the downstream temperature T_R rises slower than the upstream temperature T_F . This means the characteristics that the upstream temperature T_F is easily varied (responsiveness of the variation is higher) in response to the operating state of the engine 10 while the downstream temperature T_R is not easily deviated in response to the operating state of the engine 10. Correcting the stopping time t_s using two exhaust gas temperatures T_F and T_R having different characteristics from each other makes it possible to set a more appropriate stopping time t_s .

6. idling stop control during the execution of the sulfur purge control:

[0066] In the above embodiment, the regeneration control is assumed to be the filter regeneration control. Alternatively, the setter 5 may set the stopping time t_s on the basis of the sulfur accumulation amount E and the sulfur removed amount R estimated by the estimator 2 when the idling stop controller 4 determines that "the idling stop condition is satisfied" during the regeneration controller 3 is executing the sulfur purge control.

[0067] Specifically, similarly to the above described setting of the stopping time t_s on the basis of the PM deposit amount A and the PM combustion amount B, the stopping time t_s may be set on the basis of the map of FIG. 2A that defines the relationship between the sulfur accumulation amount E and the stopping time (third stopping time t_{sE}) and/or the map of FIG. 2D that defines the relationship between the sulfur removed amount R and the stopping time (fourth stopping time t_{sR}) according to a method similar to any one of the first to third setting methods described above. In FIG. 2C, the stopping time t_s set to be shorter as the sulfur accumulation amount E is larger, and if the sulfur accumulation amount E is larger than a first threshold E1, the stopping time t_s is set to zero while if the sulfur accumulation amount E is equal to the first threshold E1, the stopping time t_s is set to be the minimum time t_{s1} . In FIG. 2D, the stopping time t_s is set to be shorter as the sulfur removed amount R is smaller, and if the sulfur removed amount R is smaller than a second threshold R1, the stopping time t_s is set to zero while if the sulfur removed amount R is equal to the second threshold R1, the stopping time t_s is set to be the minimum time t_{s1} . The minimum time t_{s1} is set to be a value that does not make the passenger to feel uncomfortable due to idling stop and may be the same as or different from the above minimum time t_{s0} . Here, the first threshold E1 and the second threshold R1 are different from the above first threshold A1 and the second threshold B1, respectively.

[0068] If the idling stop condition is satisfied during the execution of the sulfur purge control, the setter 5 may set the stopping time t_s to zero irrespective of the sulfur accumulation amount E and the sulfur removed amount R . This is because, since the sulfur purge control requires higher temperature than the filter regeneration control and the NOx purge control, it is sometimes preferred that, even if the idling stop condition is satisfied, the engine 10 is not stopped and the high-temperature state of the engine 10 is maintained until the sulfur purge control is finished, depending on other conditions of, for example, the temperature of trap catalyst 14C. This prevents the sulfur purge control from taking a longer time and therefore an amount of fuel consumed by the sulfur purge control can be reduced.

[0069] If the regeneration controller 3 carries out the sulfur purge control immediately after the end of the filter regeneration control as the above, the high-temperature state of the filter regeneration can be taken over by the sulfur purge control, so that the amount of temperature rise can be suppressed to be low. However in this case, as shown in FIG. 7B, the stopping time t_s , which is set to zero at the initial phase of the filter regeneration control, may be prolonged as the control proceeds and reset to zero at the start of the sulfur purge control after the end of the filter regeneration control. For the above, idling of the engine 10 may be stopped before the start of the sulfur purge control (i.e., the final phase of the filter regeneration control) but idling of the engine 10 may not be stopped after the transition to the sulfur purge control, and consequently, this may make the passenger feel uncomfortable.

[0070] As a solution to the above, only when the idling stop is first satisfied under a state where the sulfur purge control is carried out in succession to the filter regeneration control, the setter 5 sets the stopping time t_s to be the minimum time t_{s0} . Namely, even if the sulfur purge control is being carried out but if this sulfur purge control is carried out in succession to the filter regeneration control, the stopping time t_s is not set straightly to zero but is set only once to the minimum time t_{s0} . This makes the passenger less feel uncomfortable and an amount of temperature decline of the trap catalyst 14C during the automatic stop of the engine 10 can be minimized.

7. others:

[0071] In the above embodiment, the stopping time t_s is corrected using both the upstream temperature T_F and the downstream temperature T_R . In addition to this, if one of the exhaust gas temperatures T_F and T_R is equal to or lower than the first temperature T_{F1} and T_{R1} , respectively, the setter 5 may correct the stopping time t_s to decrease more as the intake air temperature T_{IN} is lower. For example, one of the solutions to the above may cause the setter 5 to obtain a coefficient $K3$ to correct the stopping time t_s by applying an intake air temperature T_{IN} to the map of FIG. 4 and then add a term of multiplying the obtained coefficient $K3$ to the right side of the above expression 1. As described, correcting the stopping time t_s by also considering the intake air temperature T_{IN} can enhance the temperature rise of the processors, so that the time for the regeneration can be further reduced, thereby reducing an amount of fuel consumed during the regeneration control. Further alternatively, the setter 5 may correct the stopping time t_s on the basis of one of the upstream temperature T_F and the downstream temperature T_R or may omit the correction based on the upstream temperature T_F and the downstream temperature T_R .

REFERENCE SIGNS LIST

[0072]

- 1 controller
- 2 estimator
- 3 regeneration controller
- 4 idling stop controller
- 5 setter
- 10 engine
- 14 exhaust gas purification device
- 14B filter (processor)
- 14C trap catalyst (processor)
- 20 intake air temperature sensor
- 21, 22, 23 exhaust gas temperature sensor
- A PM deposit amount (trapped amount)
- A1 first threshold
- B PM combustion amount (removed amount)
- B1 second threshold
- E sulfur accumulation amount
- E1 first threshold
- R S sulfur removed amount (removed amount)

R1 second threshold
 ts stopping time
 ts₀, ts₁ minimum time
 T_F upstream temperature (upstream exhaust gas temperature)
 T_{F1} first upstream temperature (first temperature)
 T_{F2} second upstream temperature (second temperature)
 T_R downstream temperature (downstream exhaust gas temperature)
 T_{R1} first downstream temperature (first temperature)
 T_{R2} second downstream temperature (second temperature)

[0073] The invention thus described, it will be obvious that the same may be varied in many ways. Such variations are not to be regarded as a departure from the spirit and scope of the invention, and all such modifications as would be obvious to one skilled in the art are intended to be included within the scope of the following claims.

Claims

1. A controller (1) that controls an internal combustion engine (10) comprising a processor (14B, 14C) that traps a predetermined substance contained in exhaust gas and processes the substance, the controller (1) comprising:
 - an estimator (2) that estimates a trap amount (A, E) of the substance trapped by the processor (14B, 14C) ;
 - a regeneration controller (3) that carries out, when a predetermined regeneration condition is satisfied, regeneration control that removes the substance from the processor (14B, 14C);
 - a setter (5) that sets, when a predetermined idling stop condition is satisfied while the regeneration control is being carried out, a stopping time (ts) of the internal combustion engine (10), the stopping time (ts) being based on the trap amount (A, E); and
 - an idling stop controller (4) that stops, when the stopping time (ts) is set, the internal combustion engine (10) for the stopping time (ts) from the time point at which the predetermined idling stop condition is satisfied.
2. The controller (1) according to claim 1, wherein the setter (5) sets the stopping time (ts) to be longer as the trap amount (A, E) is less.
3. The controller (1) according to claim 1 or 2, wherein the setter (5) sets the stopping time (ts) to zero when the trap amount (A, E) exceeds a first threshold (A1, E1).
4. The controller (1) according to claim 3, wherein the setter (5) sets the stopping time (ts) to be equal to or more than a minimum time (ts₀, ts₁) when the trap amount (A, E) is equal to or less than the first threshold (A1, E1).
5. The controller (1) according to one of claims 1-4, wherein the estimator (2) estimates a removed amount (B, R) of the substance removed from the processor (14B, 14C) since the regeneration control has started; and the setter (5) obtains two of the stopping times (ts_A, ts_B; ts_E, ts_R) each of which is based on respective one of the trap amount (A; E) and the removed amount (B; R) and sets a shorter one of the two obtained stopping times (ts_A, ts_B; ts_E, ts_R) to be the stopping time (ts).
6. The controller (1) according to claim 5, wherein the estimator (2) estimates the removed amount (B, R) using a parameter different from a parameter used to estimate the trap amount (A, E).
7. The controller (1) according to one of claims 1-6, further comprising an exhaust gas temperature sensor (21, 22, 23) that measures an exhaust gas temperature of at least one of an upstream side or a downstream side of the processor (14B, 14C), wherein, when the exhaust gas temperature is equal to or lower than a first temperature, the setter (5) corrects the stopping time (ts) to a smaller value as the exhaust gas temperature is lower.
8. The controller (1) according to claim 7, wherein, when the exhaust gas temperature is equal to or lower than a second temperature lower than the first temperature, the setter (5) corrects the stopping time (ts) to zero.
9. The controller (1) according to claim 7 or 8, further comprising:

EP 3 153 687 A1

an intake air temperature sensor (20) that measures an intake air temperature, wherein,
when the exhaust gas temperature is equal to or lower than the first temperature, the setter (5) corrects the
stopping time (ts) to a smaller value as the intake air temperature is lower.

- 5 **10.** The controller (1) according to one of claims 1-9, wherein the processor (14B, 14C) comprises a trap catalyst (14C)
that is capable of occluding a sulfur component in exhaust gas;

the regeneration controller (3) carries out sulfur purge control that removes the sulfur component from the trap
catalyst (14C); and
10 when the idling stop condition is satisfied while the sulfur purge control being carried out, the setter (5) sets the
stopping time (ts) to zero.

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FIG. 1

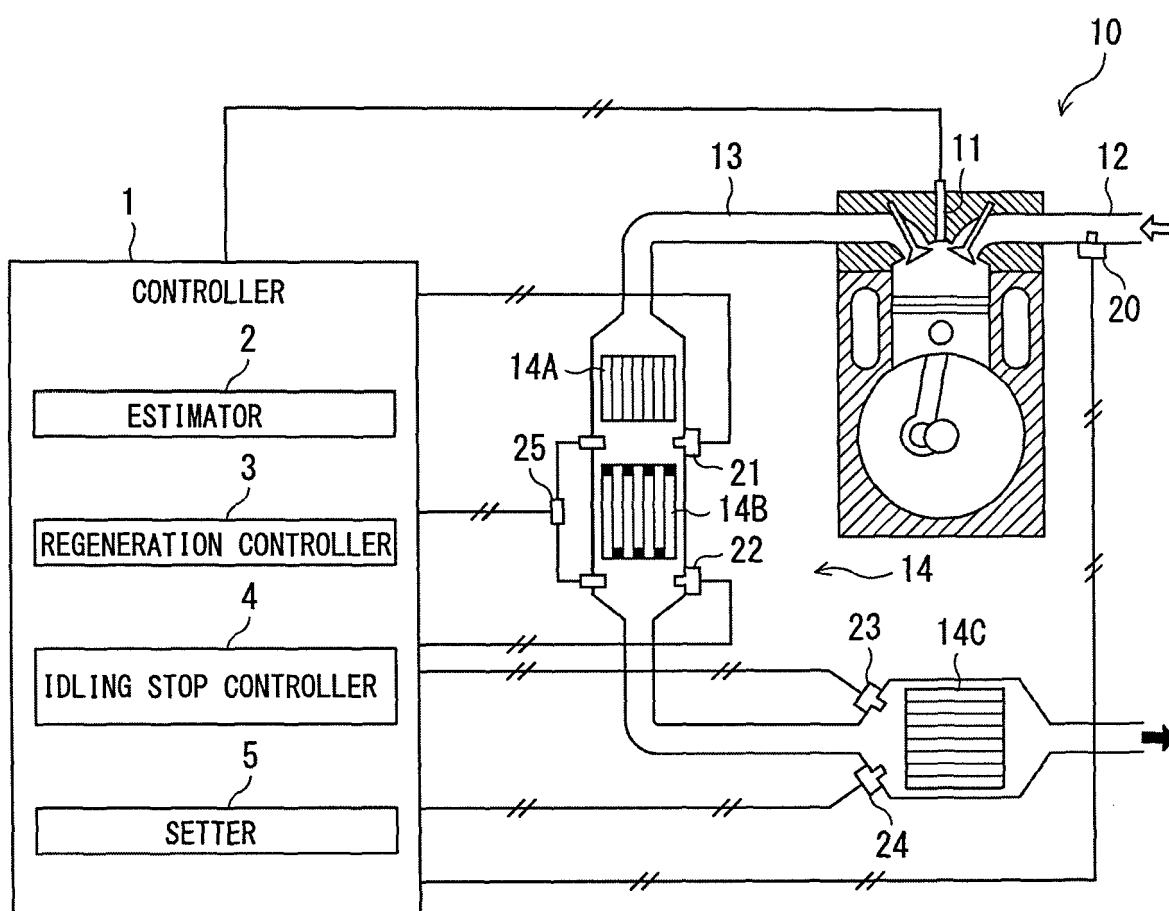


FIG. 2A

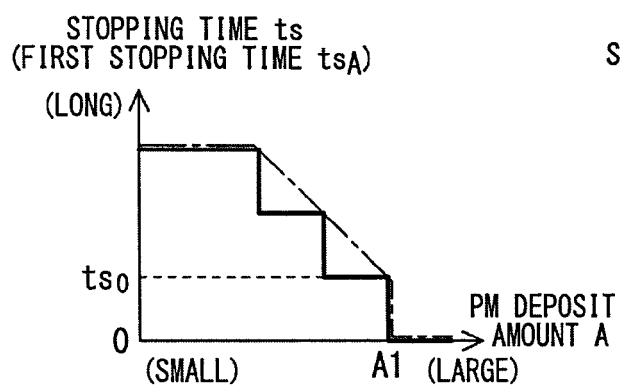


FIG. 2B

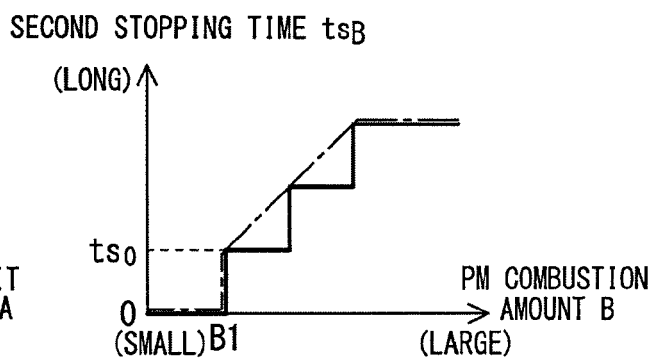


FIG. 2C

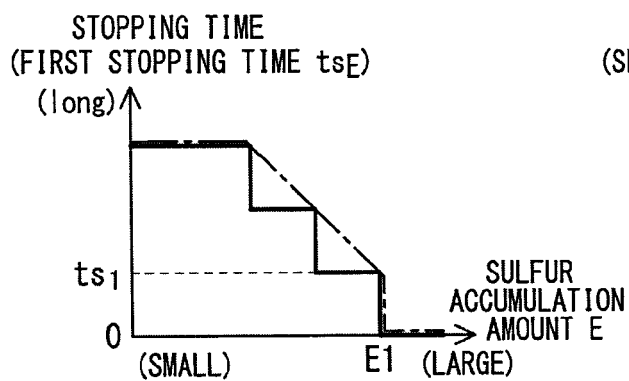


FIG. 2D

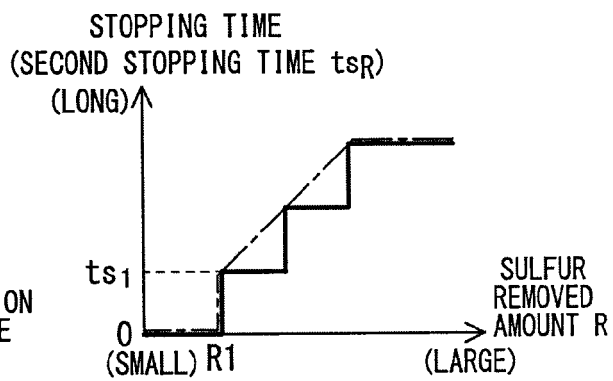


FIG. 3A

FIRST COEFFICIENT K_1

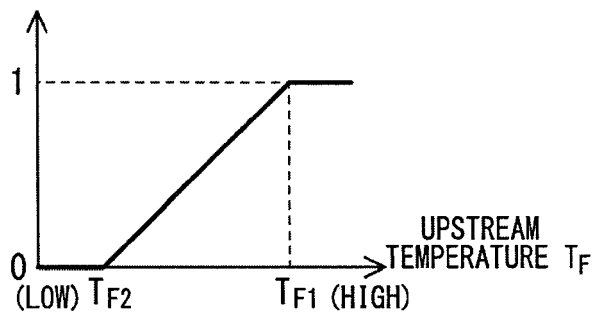


FIG. 3B

SECOND COEFFICIENT K_2

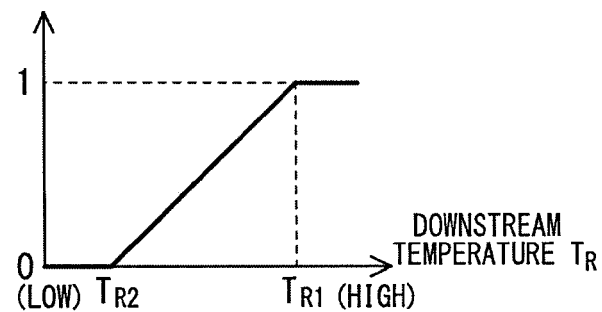


FIG. 4

THIRD COEFFICIENT K_3

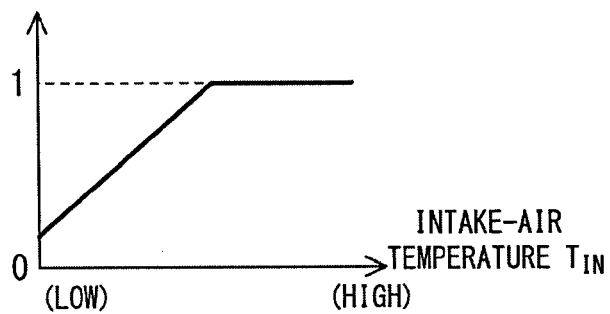


FIG. 5

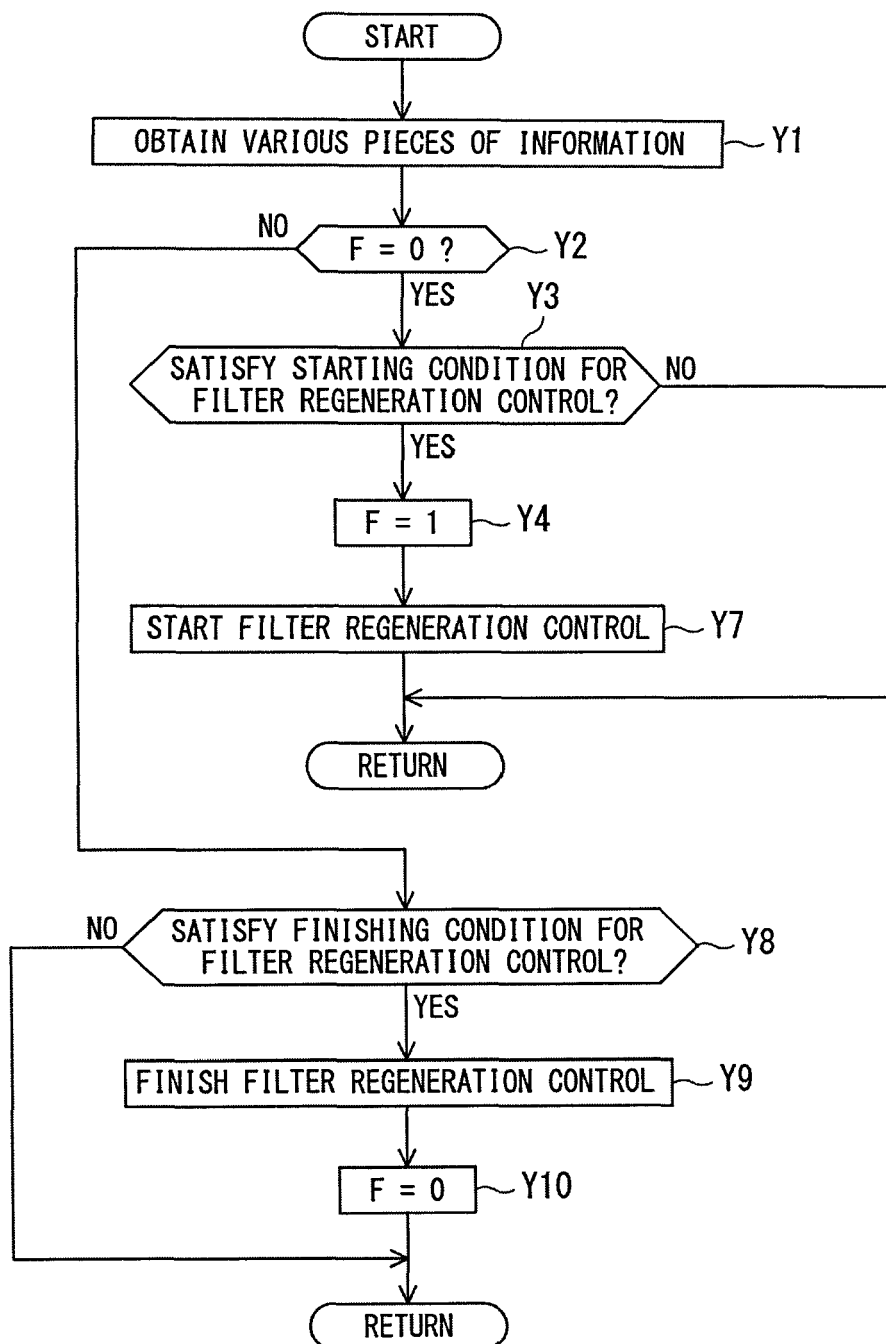
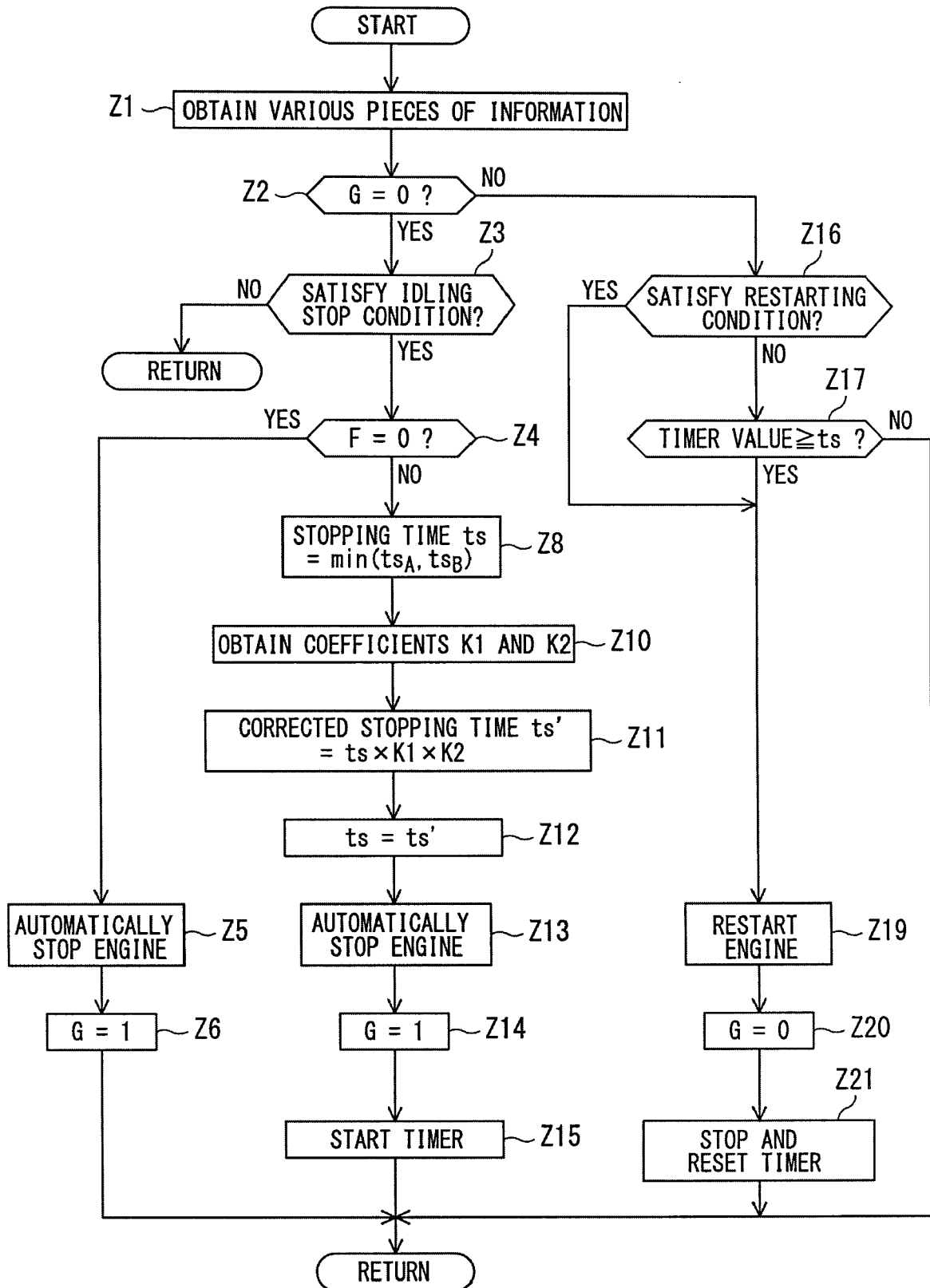
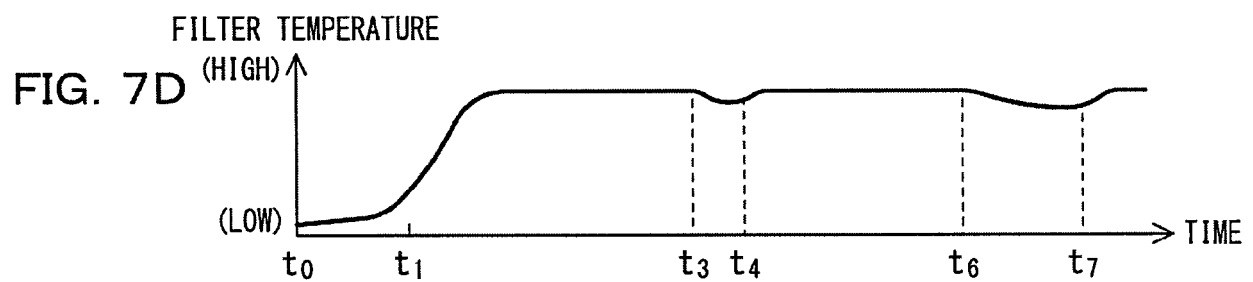
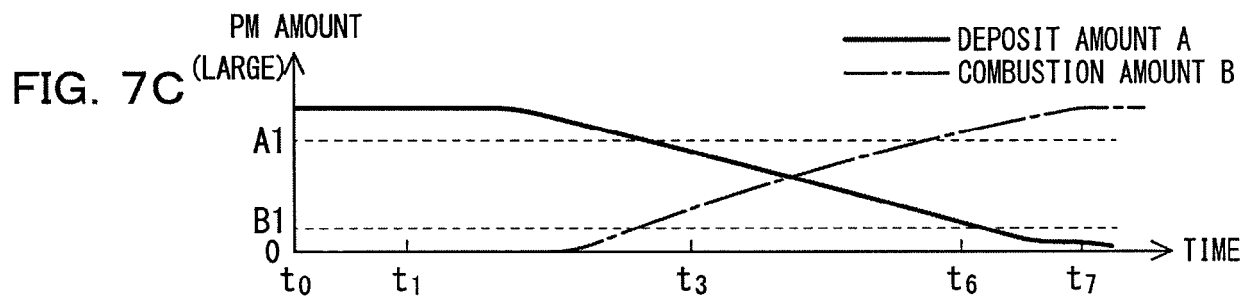
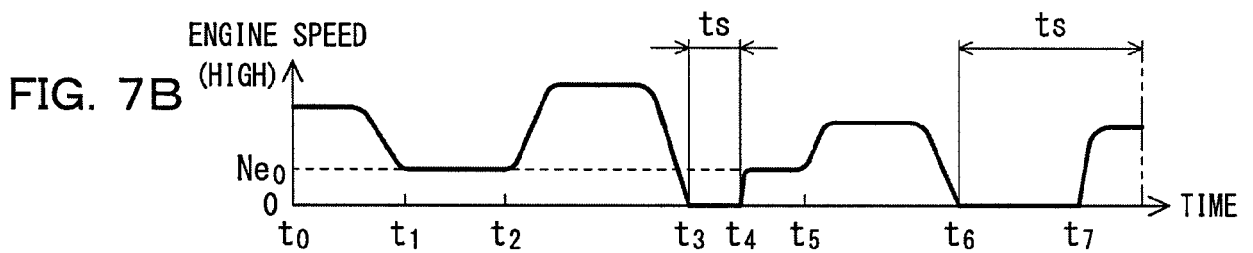
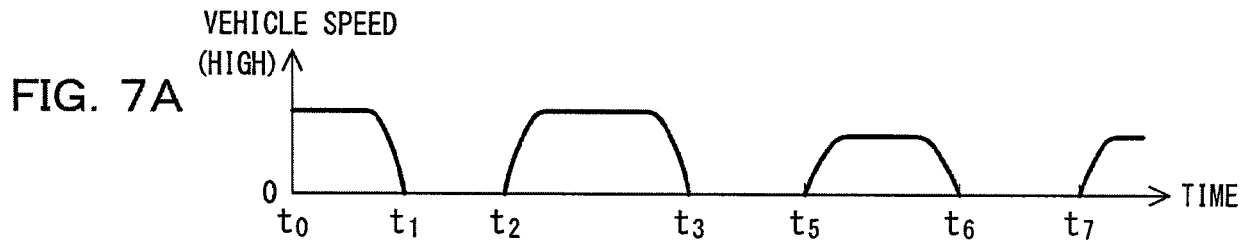
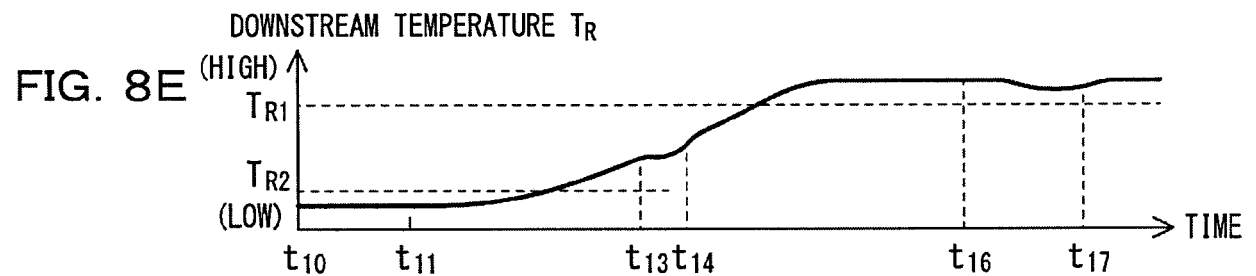
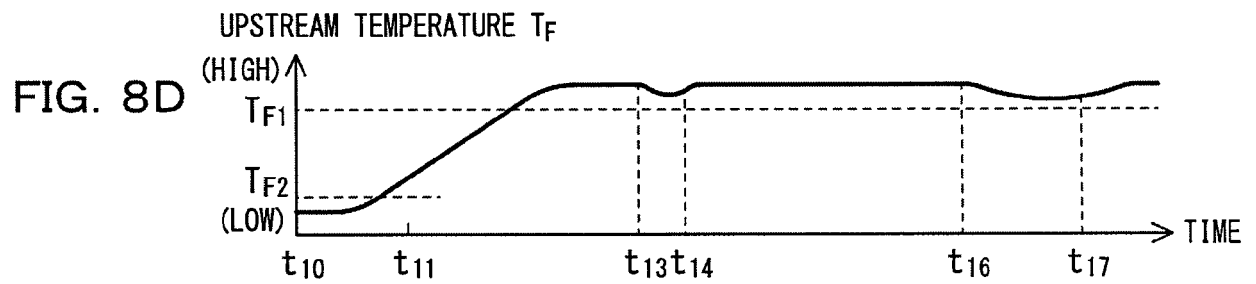
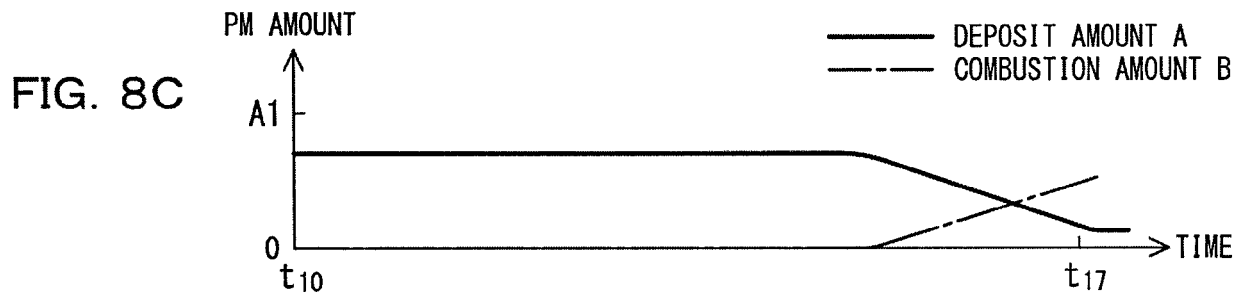
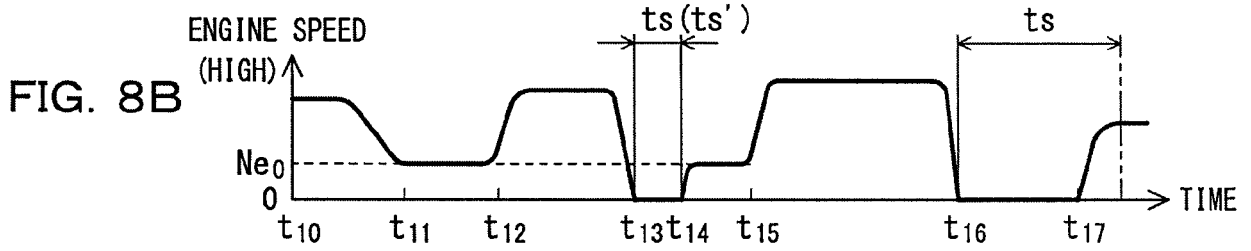
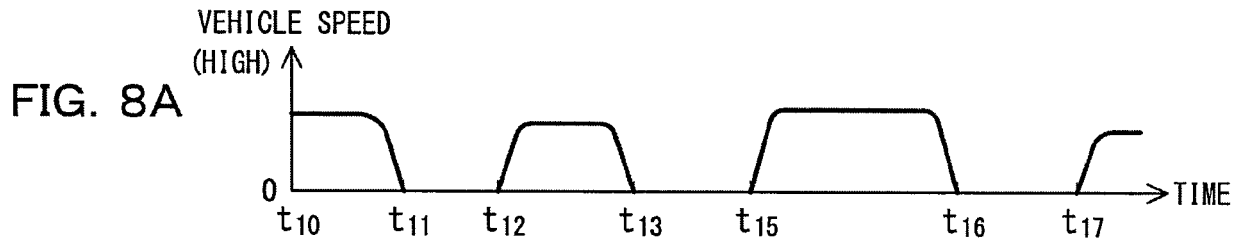


FIG. 6









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