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(54) **CONTROL DEVICE OF INTERNAL COMBUSTION ENGINE**

(57) [Object]

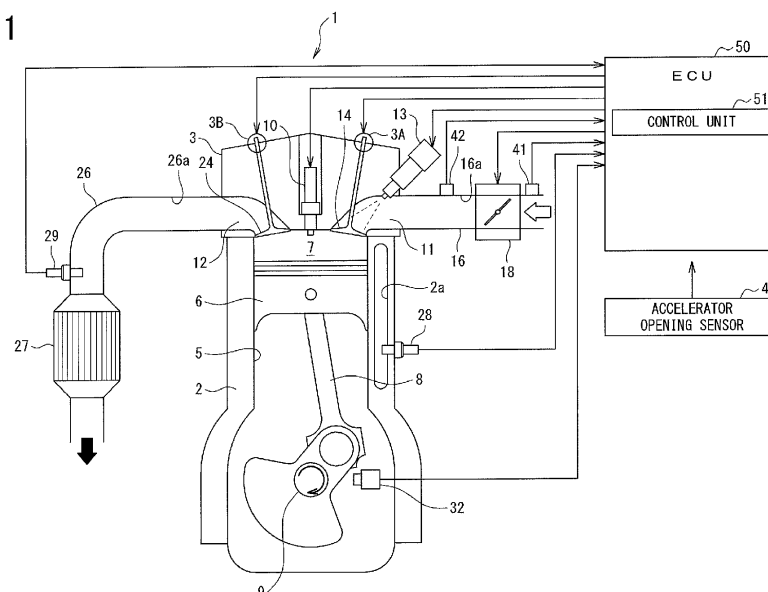
It is to provide a control device of an internal combustion engine capable of efficiently starting the internal combustion engine at a recovery from a fuel cut.

[Solution]

There are provided: cylinders 5; an intake variable valve mechanism 3A to change valve opening and closing characteristics of intake valves 14 of the cylinders; an exhaust variable valve mechanism 3B to change valve opening and closing characteristics of exhaust valves 24

of the cylinders; and a control unit 51 to perform an exhaust introduction control of respectively closing and opening, while a fuel-supply to the cylinder(s) is stopped, the intake and exhaust valves using the intake and exhaust variable valve mechanisms. If there is an all-cylinders fuel cut request for stopping the fuel-supply to all the cylinders, the control unit introduces a fresh air into all the cylinders and thereafter, performs the exhaust introduction control.

FIG. 1



Description

[Technical Field]

[0001] The present invention relates to a control device of an internal combustion engine.

[Background Art]

[0002] Patent Literature 1 discloses a control device of an engine including a variable cylinder system to operate/deactivate cylinders of the engine under a predetermined operation condition, and a variable valve timing mechanism to variably control opening/closing timing of respective intake and exhaust valves, in which an ECU opens an exhaust bypass valve on an exhaust bypass passage while closing the intake valve of the deactivated cylinder, to thereby introduce into the deactivated cylinder a part of the exhaust gas from an exhaust pipe of the operated cylinder.

[Citation List]

[Patent Literature]

[0003] [Patent Literature 1] JP 2006-336579 A

[Summary of Invention]

[Technical Problem]

[0004] However, in Patent Literature 1, upon restarting a fuel supply to the fuel-supply stopped cylinder, there is in the fuel-supply stopped cylinder a shortage of an air necessary for a combustion and thus, firstly a fresh air is necessary to be introduced into the cylinders. For this reason, it is difficult to quickly restart the engine.

[0005] Thus, an object of the present invention is to provide a control device of an internal combustion engine capable of efficiently starting the internal combustion engine at a recovery from a fuel cut.

[Solution to Problem]

[0006] According to an aspect of the present invention, there is provided a control device of an internal combustion engine, the internal combustion engine including: cylinders each including intake and exhaust valves; an intake variable valve mechanism to change valve opening and closing characteristics of the intake valves; and an exhaust variable valve mechanism to change valve opening and closing characteristics of the exhaust valves, the control device including a control unit to perform an exhaust introduction control of respectively closing and opening, during a fuel-cut to the cylinder, the intake and exhaust valves of the fuel-cut cylinder using the intake and exhaust variable valve mechanisms to thereby introduce a gas of a downstream of the fuel-cut cylinder there-

into, wherein if there is an all-cylinders fuel cut request for stopping a fuel-supply to all the cylinders, the control unit introduces a fresh air into all the cylinders and thereafter, performs the exhaust introduction control for all the cylinders.

[Advantageous Effect of Invention]

[0007] According to the present invention, it is possible to efficiently start an internal combustion engine at a recovery from a fuel cut.

[Brief Description of Drawings]

[0008]

Fig. 1 is a diagram showing an internal combustion engine and a control device thereof according to an embodiment of the present invention.

Fig. 2 is a flow chart showing procedures of an in-fuel-cut exhaust introduction request determination to be performed in the control device.

Fig. 3 is a flow chart showing procedures of an in-fuel-cut exhaust introduction control process to be performed in the control device.

[Description of Embodiment]

[0009] A control device according to an embodiment of the present invention is mounted on an internal combustion engine, the internal combustion engine including: cylinders each including intake and exhaust valves; an intake variable valve mechanism to change valve opening and closing characteristics of the intake valves; and an exhaust variable valve mechanism to change valve opening and closing characteristics of the exhaust valves, the control device including a control unit to perform an exhaust introduction control of respectively closing and opening, during a fuel-cut to the cylinder, the intake and exhaust valves of the fuel-cut cylinder using the intake and exhaust variable valve mechanisms to thereby introduce a gas of a downstream of the fuel-cut cylinder thereinto, wherein if there is an all-cylinders fuel cut request for stopping a fuel-supply to all the cylinders, the control unit introduces a fresh air into all the cylinders and thereafter, performs the exhaust introduction control for all the cylinders.

[0010] Accordingly, the control device according to the embodiment of the present invention can efficiently start the internal combustion engine at a recovery from a fuel cut.

[Embodiment]

[0011] Hereinafter, referring to Figs., a control device of an internal combustion engine according to an embodiment of the present invention will be described in detail.

[0012] As shown in FIG. 1, an internal combustion en-

gine 1 according to an embodiment of the present invention is of a gasoline engine with e.g., four-cylinders in series. The number of the cylinders is not limited to four, in the internal combustion engine 1. Additionally, the internal combustion engine 1 is not limited to the gasoline engine, but may be a diesel engine.

[0013] The internal combustion engine 1 includes a cylinder block 2, and a cylinder head 3 fastened to an upper portion of the cylinder block 2. The cylinder block 2 is formed with a plurality of cylinders 5. Each cylinder 5 is accommodated with a piston 6 to reciprocate therewithin in an up-down direction. Additionally, in each cylinder 5, a combustion chamber 7 is defined at an upper portion thereof.

[0014] The internal combustion engine 1 is configured to perform, for each cylinder 5, a series of four steps of an intake step, a compression step, an expansion step and an exhaust step while the corresponding piston 6 reciprocates twice within the corresponding cylinder 5, which is so-called four-strokes engine.

[0015] Each of the pistons 6 is connected to a crankshaft 9 through a connecting rod 8. Each of the connecting rods 8 is configured to convert the reciprocating motion of the corresponding piston 6 into a rotating motion of the crankshaft 9.

[0016] Note that the crankshaft 9 is connected with an auxiliary device (not shown) such as a starter or an ISG (Integrated Starter Generator) to rotate the crankshaft 9 with electric power supplied from a battery (not shown).

[0017] The cylinder head 3 is provided with, for each cylinder 5, an ignition plug 10, an intake port 11, and an exhaust port 12. Each of the ignition plugs 10 protrudes an electrode thereof into the corresponding combustion chamber 7, of which an ignition timing is adjusted by an igniter (not shown).

[0018] The intake ports 11 of the cylinder head 3 are connected with an intake pipe 16. That is, each of the intake ports 11 communicates between the corresponding combustion chamber 7 and an intake passage 16a. The intake passage 16a is formed in the intake pipe 16. Each of the intake ports 11 is provided with an intake valve 14.

[0019] The exhaust ports 12 of the cylinder head 3 are connected with an exhaust pipe 26. That is, each of the exhaust ports 12 communicates between the corresponding combustion chamber 7 and an exhaust passage 26a. The exhaust passage 26a is formed in the exhaust pipe 26. Each of the exhaust ports 12 is provided with an exhaust valve 24.

[0020] The intake valve 14 and the exhaust valve 24 are each configured to be opened/closed by the crankshaft 9 through a timing chain (not shown) or a timing belt (not shown) which is wound between the intake and exhaust valves 14, 24 and the crankshaft 9.

[0021] The intake passage 16a is provided with an electronically controlled throttle valve 18.

[0022] That is, the throttle valve 18 is electrically connected to an ECU 50 to be described later. Thus, the

throttle valve 18 is configured to regulate a throttle opening in accordance with a command signal from the ECU 50 to thereby adjust an amount of an intake air flowing into the internal combustion engine 1.

[0023] The internal combustion engine 1 also includes an injector 13 for each cylinder 5. Each of the injectors 13 is of a port injection type fuel injection valve, which is configured to inject, into the corresponding combustion chamber 7 through the corresponding intake port 11, a fuel pressure-fed from a fuel tank (not shown) by a fuel pump (not shown).

[0024] In such an internal combustion engine 1, an air in the intake passage 16a flows through the throttle valve 18 to adjust a flowing rate of the air, to thereafter be introduced into each of the intake ports 11. The introduced air into the intake ports 11 is mixed with the injected fuel from the injectors 13. The mixed air is introduced into the combustion chambers 7.

[0025] On the exhaust passage 26a, a catalyst 27 is provided. The catalyst 27 is configured to purify the exhaust gas from the combustion chamber 7. The catalyst 27 is of a three-way catalyst to purify hazardous substances of a hydrocarbon (HC), a carbon monoxide (CO), and a nitrogen oxide (NOx) at the same time. These hazardous substances are included in the exhaust gas. Such a catalyst is configured to exhibit, at a theoretical air fuel ratio, an exhaust gas purification performance at the maximum.

[0026] The internal combustion engine 1 also includes a water temperature sensor 28, an O2 sensor 29, a crank angle sensor 32, an intake air temperature sensor 41, an air flow sensor 42, and an accelerator opening sensor 43.

[0027] The water temperature sensor 28 is configured to detect temperature (cooling water temperature) of a cooling water flowing through a water jacket 2a formed in the cylinder block 2, i.e., engine water temperature.

[0028] The O2 sensor 29 is provided upstream of the catalyst 27 (i.e., on an exhaust path, the O2 sensor 29 is closer to the exhaust port 12 than the catalyst 27 is). The O2 sensor 29 is of an oxygen sensor having an output characteristic where an output for an air fuel ratio is largely different between rich and lean sides of the theoretical air fuel ratio. Instead of the O2 sensor 29, an A/F sensor having an output characteristic where an output for an air fuel ratio is linear may be used.

[0029] The crank angle sensor 32 is configured to detect a rotation angle of the crankshaft 9 and output the detection signal to the ECU 50. In other words, the crank angle sensor 32 is configured to detect an engine rotation speed.

[0030] The intake air temperature sensor 41 is configured to detect temperature (intake air temperature) of an air in the intake passage 16a upstream of the throttle valve 18 (i.e., an air in the intake passage 16a to flow into the throttle valve 18) and output the detection signal to the ECU 50.

[0031] The air flow sensor 42 is configured to detect an amount (intake air amount) of an air in the intake pas-

sage 16a downstream of the throttle valve 18 (i.e., an air in the intake passage 16a to flow into the intake ports 11) and output the detection signal to the ECU 50.

[0032] The accelerator opening sensor 43 is configured to detect a depression amount (accelerator opening) of an accelerator pedal (not shown) and output the detection signal to the ECU 50.

[0033] The internal combustion engine 1 also includes an intake variable valve mechanism 3A and an exhaust variable valve mechanism 3B. The intake variable valve mechanism 3A is provided on a camshaft (not shown) for the intake valves 14, which is configured to regulate a valve timing (opening/closing timing) of each of the intake valves 14. Specifically, the intake variable valve mechanism 3A is configured to adjust (e.g., advance/delay) opening and closing timings at which the respective intake valves 14 are opened/closed, to thereby open/close the respective intake valves 14 at desired timings.

[0034] Similarly, the exhaust variable valve mechanism 3B is provided on another camshaft (not shown) for the exhaust valves 24, which is configured to regulate a valve timing (opening/closing timing) of each of the exhaust valves 24. Specifically, the exhaust variable valve mechanism 3B is configured to adjust (e.g., advance/delay) opening and closing timings at which the respective exhaust valves 24 are opened/closed, to thereby open/close the respective exhaust valves 24 at desired timings.

[0035] Such an internal combustion engine 1 is configured to control the operation state thereof using the Engine Control Unit (ECU) 50 as a control device for the internal combustion engine. The ECU 50 is constituted by a microcomputer including e.g., a Central Processing Unit (CPU), a Random Access Memory (RAM), a Read Only Memory (ROM), input and output interfaces, and the like. The CPU is configured to use a temporary storage function of the RAM and perform a signal process in accordance with a program stored in the ROM in advance. The ROM also stores various control constants, various maps, and the like in advance.

[0036] The ECU 50 is communicatably connected with, at an input side thereof, various sensors such as the water temperature sensor 28, the O₂ sensor 29, the crank angle sensor 32, the intake air temperature sensor 41, the air flow sensor 42, and the accelerator opening sensor 43, through a communication line of a standard such as CAN.

[0037] On the other hand, the ECU 50 is communicatably connected with, at an output side thereof, various devices such as the ignition plugs 10, the injectors 13, the throttle valve 18, the intake variable valve mechanism 3A, and the exhaust variable valve mechanism 3B, through a communication line of a standard such as CAN.

[0038] Thus, the ECU 50 is configured to independently control the cylinders 5, so as to adjust the ignition timing of each ignition plug 10, the injection timing of each injector 13, the opening and closing timings of each intake

valve 14, the opening and closing timings of each exhaust valve 24, and the like.

[0039] As mentioned above, the ECU 50 controls each of the ignition plugs 10, each of the injectors 13, the throttle valve 18, the intake variable valve mechanism 3A, and the exhaust variable valve mechanism 3B, based on an operation of the driver and/or an operation state of the internal combustion engine 1. Additionally, the ECU 50 has a communication function of communicating with the various sensors, the various devices (including actuators and the like), and other control units. For example, the ECU 50 controls energization to each of the injectors 13, to thereby regulate the corresponding fuel injection timing and amount.

[0040] The ECU 50 determines that there is a fuel-cut request and performs a fuel cut of stopping a fuel injection to the internal combustion engine 1, under predetermined conditions one of which is that the accelerator pedal is not depressed.

[0041] At performing the fuel cut, the ECU 50 stops a fuel injection(s) into a part of or all the cylinders 5, in accordance with the operation state of the internal combustion engine 1.

[0042] The ECU 50 determines that an in-fuel-cut exhaust introduction request is established, if the current engine water temperature is not higher than a predetermined water temperature set value or if the intake air temperature is not higher than a predetermined intake air temperature set value.

[0043] The ECU 50 includes a control unit 51 to perform an exhaust introduction control of closing the intake valve(s) 14 and opening the exhaust valve(s) 24 using the respective intake and exhaust variable valve mechanisms 3A, 3B while reciprocating the piston(s) 6. The control unit 51 performs, when there is a fuel cut request with the in-fuel-cut exhaust introduction request established, the exhaust introduction control during the fuel cut.

[0044] In the exhaust introduction control, while reciprocating the piston(s) 6 due to a rotation of the crankshaft 9, the intake valve(s) 14 is closed to thereby prevent a fresh air (yet-to-be combusted gas upstream of the cylinder 5) from being introduced into the cylinder(s) 5, and the exhaust valve(s) 24 is opened to thereby introduce a hot gas in the exhaust pipe 26 into the cylinder(s) 5. Thus, temperature in the fuel-cut cylinder(s) 5 is prevented from decreasing.

[0045] In a case where there is an all-cylinders fuel cut request for stopping fuel injections into all the cylinders 5, the control unit 51 introduces the fresh air into all the cylinder 5 and thereafter, performs the exhaust introduction control for all the cylinder 5.

[0046] In this case (the case there is the all-cylinders fuel cut request for stopping fuel injections into all the cylinders 5), the control unit 51 may start performing the exhaust introduction control after all the cylinders 5 are satisfied with the introduced fresh air.

[0047] Specifically, in the case where there is the all-

cylinders fuel cut request, the control unit 51 performs a cycle ventilation with a first set value of a predetermined cycle number for all the cylinders 5 (i.e., rotates, without the fuel injections into all the cylinders 5, the crankshaft 9 by the first set value (e.g., one-cycle corresponds to one-reciprocation of the piston 6) to thereby actuate the piston 6 and the intake and exhaust valves 14, 24 in each cylinder 5 so as to open the intake valves 14/exhaust valves 24 in the downstroke/upstroke of each piston 6 with the exhaust valves 24/intake valves 14 closed) and thereafter, performs the exhaust introduction control for all the cylinders. Note that the first set value is set as a cycle number necessary for satisfying all the cylinders 5 with the fresh air during the fuel cut. The first set value is calculated based on e.g., an inner EGR ratio of the internal combustion engine 1.

[0048] The reason why at the all-cylinders fuel cut the fresh air is introduced before the exhaust introduction control is performed that the fresh air is satisfied in the exhaust pipe 26 and the cylinders 5 to thereby allow, in response to a re-depression to the accelerator pedal, a fuel to be injected into the cylinders to immediately output power.

[0049] Contrastively, in a case of fuel cut for not all but a part of the cylinders 5, the control unit 51 firstly performs the exhaust introduction control for the fuel-cut cylinder(s) 5, and thereafter at a recovery from the fuel cut, introduces the fresh air into the fuel-cut cylinder(s) 5 to thereby re-operate it.

[0050] In this case, the control unit 51 may re-operate the fuel-cut cylinder(s) 5 after the fuel-cut cylinder(s) 5 is satisfied with the introduced fresh air.

[0051] Specifically, in the case of fuel cut for a part of the cylinders 5, when the fuel cut for the part of the cylinders 5 is stopped after the exhaust introduction control is performed therefor, the control unit 51 re-operates the fuel-cut cylinder(s) 5 after a cycle ventilation with a second set value of a predetermined cycle number as well as the above-mentioned first set value cycle ventilation is performed for the fuel-cut cylinder(s) 5 (i.e., after the crankshaft 9 rotates by the second set value to thereby actuate the piston 6 and the intake and exhaust valves 14, 24 in each cylinder 5 as the above-mentioned first set value cycle ventilation). Note that the second set value is set as a cycle number necessary for satisfying the fuel-cut cylinder 5 with the fresh air before the fuel injection is restarted. The second set value is calculated based on e.g., an inner EGR ratio of the corresponding cylinder 5.

[0052] In such a fuel cut for the part of the cylinders 5, the exhaust pipe 26 includes therein an exhaust gas from the other cylinder(s) 5 (combusted gas from the fuel-injected cylinder(s) 5), and thus, even if a control similar to that for the all-cylinder fuel cut is performed, the fresh air is mixed with the exhaust gas from the other cylinder(s) 5 to thereby disenable the fresh air to be immediately combusted. However, such an output delay does not cause any problem since the other cylinder(s) 5, for

which the fuel cut is not performed, can compensate for the output delay by e.g., adjusting the ignition timing of the other cylinder(s) 5. Thus, in such a partial fuel-cut, prevention for temperature decrease in the fuel-cut cylinder(s) 5 is prioritized and hence, the fresh air is introduced at a recovery from the fuel cut after the exhaust introduction control is performed.

[0053] Next, referring to FIG. 2, an in-fuel-cut exhaust introduction request determination process of determining whether or not the exhaust introduction control is necessary to be performed during a fuel cut, to be performed in the above-mentioned control device according to the present embodiment, will be explained. Note that the in-fuel-cut exhaust introduction request determination process to be explained later is started upon starting the ECU 50.

[0054] At step S1, the ECU 50 acquires data of both the current engine water temperature and the current intake air temperature. After step S1, the ECU 50 proceeds to step S2.

[0055] At step S2, using the acquired data, the ECU 50 determines whether or not the engine water temperature is the water temperature set value or lower.

[0056] If determines that the acquired engine water temperature is the water temperature set value or lower, the ECU 50 proceeds to step S4. Otherwise (if determines that the acquired engine water temperature is not the water temperature set value or lower), the ECU 50 proceeds to step S3.

[0057] At step S3, using the acquired data, the ECU 50 determines whether or not the intake air temperature is the intake air temperature set value or lower.

[0058] If determines that the acquired intake air temperature is the intake air temperature set value or lower, the ECU 50 proceeds to step S4. Otherwise (if determines that the acquired intake air temperature is not the intake air temperature set value or lower), the ECU 50 proceeds to step S5.

[0059] At step S4, the ECU 50 determines that an in-fuel-cut exhaust introduction request is established. After step S4, the ECU 50 returns to step S1 to repeat this process.

[0060] At step S5, the ECU 50 determines that the in-fuel-cut exhaust introduction request is non-established. After step S5, the ECU 50 returns to step S1 to repeat this process.

[0061] Next, referring to FIG. 3, an in-fuel-cut exhaust introduction control process to be performed in the control device according to the present embodiment will be explained. Note that the in-fuel-cut exhaust introduction control process to be explained later is started upon starting the ECU 50, which is to be repeated at an interval to be set in advance.

[0062] At step S11, the ECU 50 determines whether the in-fuel-cut exhaust introduction request is currently established.

[0063] If determines that the in-fuel-cut exhaust introduction request is currently established, the ECU 50 pro-

ceeds to step S12. Otherwise (if determines that the in-fuel-cut exhaust introduction request is not currently established), the ECU 50 proceeds to step S18.

[0064] At step S12, the ECU 50 determines whether there is a fuel cut request.

[0065] If determines that there is the fuel cut request, the ECU 50 proceeds to step S13. Otherwise (if determines that there is no fuel cut request), the ECU 50 proceeds to step S18.

[0066] At step S13, the ECU 50 determines whether the fuel cut request is for all the cylinders.

[0067] If determines that the fuel cut request is for all the cylinders, the ECU proceeds to step S14. Otherwise (if determines that the fuel cut request is not for all the cylinders (i.e., that the fuel cut request is for a part of the cylinders)), the ECU proceeds to step S17.

[0068] At step S14, the ECU 50 determines whether the cycle ventilation with the first set value is completed for all the cylinders 5 in the fuel-cut.

[0069] If determines that the cycle ventilation with the first set value for all the cylinders 5 is completed, the ECU 50 proceeds to step S16. Otherwise (if determines that the cycle ventilation with the first set value for all the cylinders 5 is yet to be completed), the ECU 50 proceeds to step S15.

[0070] At step S15, while performing (e.g., starting or maintaining) a normal fuel-cut therefor, the ECU 50 rotates the crankshaft 9 with opening/closing of the intake and exhaust valves 14, 24 to thereby introduce (e.g., start to or continue to introduce) the fresh air into all the cylinders 5. After step S15, the ECU 50 proceeds to step S14 again. That is, the ECU 50 repeats these steps S14, S15 until the cycle ventilation with the first set value for all the cylinders 5 is completed.

[0071] At step S16 (i.e., after the cycle ventilation with the first set value for all the cylinders 5 is completed), the ECU 50 closes, with the exhaust valves 24 opened, the intake valves 14 of all the cylinders 5 to start the exhaust introduction control for all the cylinders 5. After step S16, the ECU 50 proceeds to step S11. Note that such an exhaust introduction control continues until the in-fuel-cut exhaust introduction request is non-established.

[0072] At step S17 (i.e., in a case of fuel-cut request for a part of the cylinders 5), while performing a fuel cut for the part of the cylinders 5, the ECU 50 closes, with the exhaust valve(s) 24 opened, the intake valve(s) 14 of the fuel-cut cylinder(s) 5 to start the exhaust introduction control for the fuel-cut cylinder(s) 5. After step S17, the ECU 50 proceeds to step S11. As well as the above-mentioned case of the fuel cut for all the cylinders 5, such an exhaust introduction control continues until the in-fuel-cut exhaust introduction request is non-established.

[0073] At step S18, the ECU 50 determines whether not all but a part of the cylinders 5 is in fuel-cut.

[0074] If determines that the part of the cylinders 5 is in fuel-cut, the ECU 50 proceeds to step S19. Otherwise (i.e., if all the cylinders 5 are in fuel-cut), the ECU 50 proceeds to step S21.

[0075] At step S19, the ECU 50 determines whether the cycle ventilation with the second set value is completed for the fuel-cut cylinder(s) 5.

[0076] If determines that the cycle ventilation with the second set value for the fuel-cut cylinder(s) 5 is completed, the ECU 50 proceeds to step S21. Otherwise (if determines that the cycle ventilation with the second set value for the fuel-cut cylinder(s) 5 is yet to be completed), the ECU 50 proceeds to step S20.

[0077] At step S20, the ECU 50 introduces a fresh air into the fuel-cut cylinder(s) 5. After step S20, the ECU 50 proceeds to step S19 again. That is, the ECU 50 repeats these steps S19, S20 until the cycle ventilation with the second set value for the fuel-cut cylinder(s) 5 is completed.

[0078] At step S21, the ECU 50 determines whether the in-fuel-cut exhaust introduction request is currently established.

[0079] If determines that the in-fuel-cut exhaust introduction request is currently established, the ECU 50 proceeds to step S11. Otherwise (if determines that the in-fuel-cut exhaust introduction request is not currently established), the ECU 50 terminates the in-fuel-cut exhaust introduction control process.

[0080] Thus, in the present embodiment, when there is the all-cylinders fuel cut request for stopping a fuel supply to all the cylinders 5, the ECU 50 allows all the cylinders 5 to each introduce a fresh air into the corresponding cylinder 5 and thereafter performs the exhaust introduction control, under a predetermined condition based on the water temperature, the intake air temperature, and the like.

[0081] That is, in a case where e.g., water temperature or intake air temperature is supposed to become low during the all-cylinders fuel cut, prior to the all-cylinders fuel cut, a fresh air is introduced into each of all the cylinders 5 and thereafter the exhaust introduction control is performed, thereby quickly starting the internal combustion engine 1 at a recovery from the fuel cut while preventing temperature in each cylinder 5 in fuel-cut from decreasing.

[0082] In this case, specifically, the ECU 50 starts the exhaust introduction control after all the cylinders 5 are satisfied therein with the introduced fresh air.

[0083] Thus, while a hot gas (in this case, a yet-to-be combusted gas of a fresh air, which is introduced into the exhaust pipe 26 through all the cylinders 5) in the exhaust pipe 26 prevents temperature in each cylinder 5 from decreasing, the internal combustion engine 1 can be quickly started due to unnecessary fresh-air-introduction at a recovery from the fuel cut.

[0084] On the other hand, when there is a partial-cylinder fuel cut request for stopping a fuel supply to not all but a part of the cylinders 5, the ECU 50 performs the exhaust introduction control for the part of the cylinders 5 (fuel-cut cylinder(s) 5) without the fresh-air-introduction, under the predetermined condition. Thereafter at a recovery from the fuel cut, the ECU 50 allows the fuel-

cut cylinder(s) 5 to introduce a fresh air thereinto, thereafter re-operating the fuel-cut cylinder(s) 5.

[0085] Thus, a hot gas (in this case, including an exhaust gas mainly) in the exhaust pipe 26 prevents temperature in the fuel-cut cylinder(s) 5 from decreasing. Note that at such a recovery from the fuel cut, until a fresh air is introduced into the fuel-cut cylinder(s) 5 to thereby re-operate it, the ECU 50 changes the ignition timing in the other cylinder(s) 5 for which the fuel cut is not performed, for example, thereby preventing responsiveness of the internal combustion engine 1 from decreasing.

[0086] Specifically, at the recovery from the partial-cylinder fuel cut, the ECU 50 satisfies the fuel-cut cylinder(s) 5 therein with the fresh air and thereafter, operates it.

[0087] Due thereto, it is possible to successfully recover the fuel-cut cylinder(s) 5 while preventing temperature therein from decreasing.

[0088] Note that in the present embodiment, a port injection where each of the intake ports 11 is injected with a fuel is adopted. Alternatively, an into-cylinder fuel injection where a fuel is directly injected into each of the cylinders 5 may be adopted.

[0089] Additionally, in the present embodiment, the ECU 50 performs various determinations and calculations based on information from various sensors, but not limited to this. The vehicle may include a communication unit communicable with an external device such as a server to perform them based on the information of various sensors sent from the communication unit, in which the communication unit may receive the determination and calculation results from the external device and various controls may be performed using the received determination and calculation results.

[0090] Although the embodiment of the present invention is disclosed above, it is obvious that those skilled in the art can modify it without departing from the scope of the present invention. It is intended that all such modifications and equivalents are encompassed by the claims.

[Reference Signs List]

[0091]

1: internal combustion engine
 3A: intake variable valve mechanism
 3B: exhaust variable valve mechanism
 5: cylinder
 13: injector
 14: intake valve
 24: exhaust valve
 43: accelerator opening sensor
 50: ECU
 51: control unit

(1), the internal combustion engine including:

cylinders (5) each including intake and exhaust valves (14, 24);
 an intake variable valve mechanism (3A) to change valve opening and closing characteristics of the intake valves (14); and
 an exhaust variable valve mechanism (3B) to change valve opening and closing characteristics of the exhaust valves (24),
 the control device comprising:

a control unit (51) to perform an exhaust introduction control of respectively closing and opening, during a fuel-cut to the cylinder (5), the intake and exhaust valves (14, 24) of the fuel-cut cylinder using the intake and exhaust variable valve mechanisms (3A, 3B) to thereby introduce a gas of a downstream of the fuel-cut cylinder thereinto, wherein if there is an all-cylinders fuel cut request for stopping a fuel-supply to all the cylinders (5), the control unit introduces a fresh air into all the cylinders and thereafter, performs the exhaust introduction control for all the cylinders.

2. The control device as claimed in claim 1, wherein if there is the all-cylinders fuel cut request, the control unit (51) satisfies all the cylinders with the introduced fresh air and thereafter, starts the exhaust introduction control.
3. The control device as claimed in claim 1 or 2, wherein if there is a fuel-cut request to a part of the cylinders (5), the control unit (51) performs the exhaust introduction control for the part of the cylinders and thereafter, introduces a fresh air into the part of the cylinders to re-operate it.
4. The control device as claimed in claim 3, wherein if there is the fuel-cut request to the part of the cylinders (5), the control unit (51) satisfies, after the exhaust introduction control for the part of the cylinders, the part of the cylinders with the introduced fresh air to thereafter re-operate it.

Claims

1. A control device of an internal combustion engine

FIG. 1

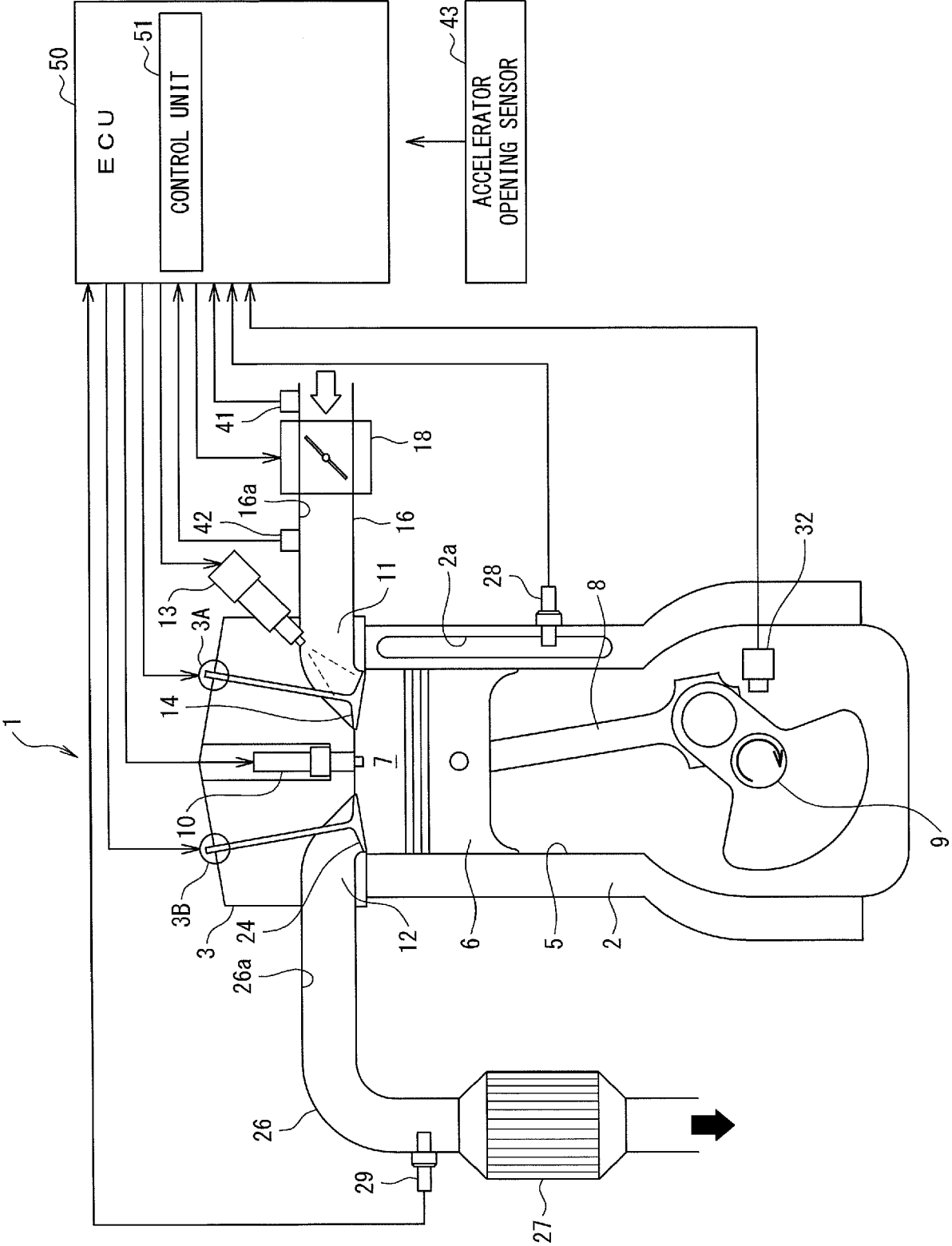


FIG. 2

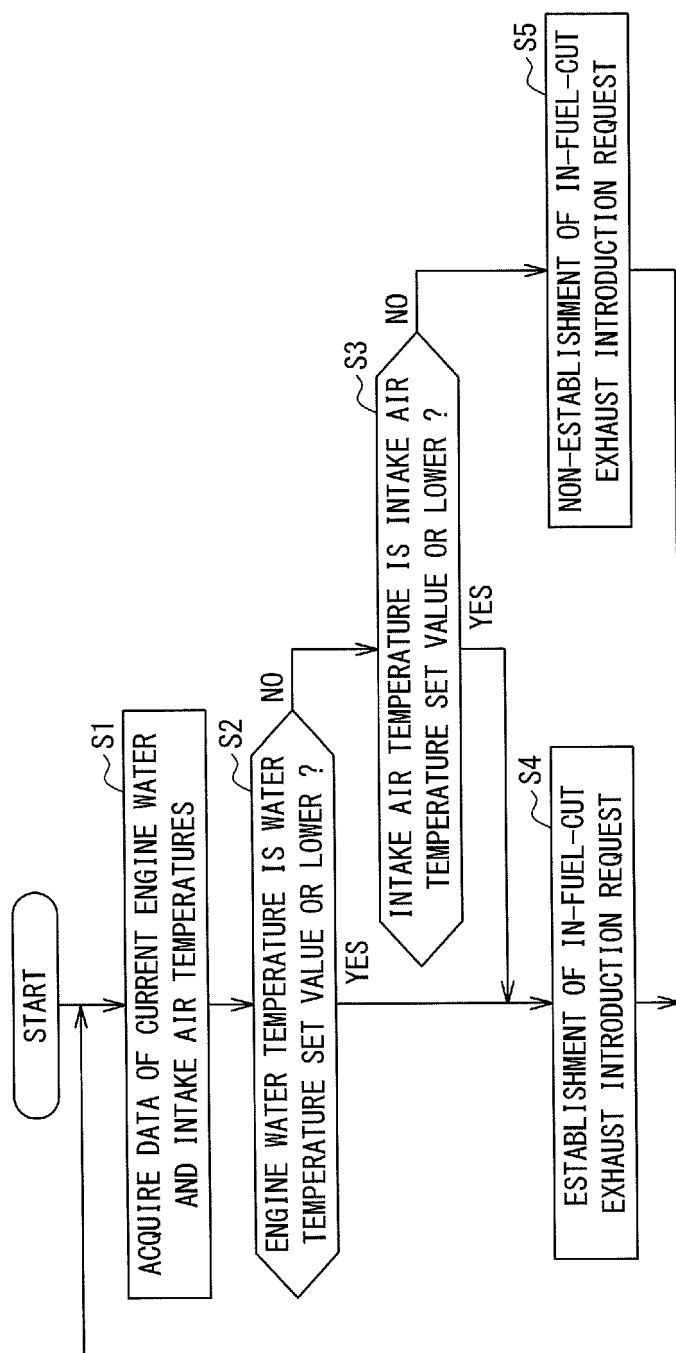
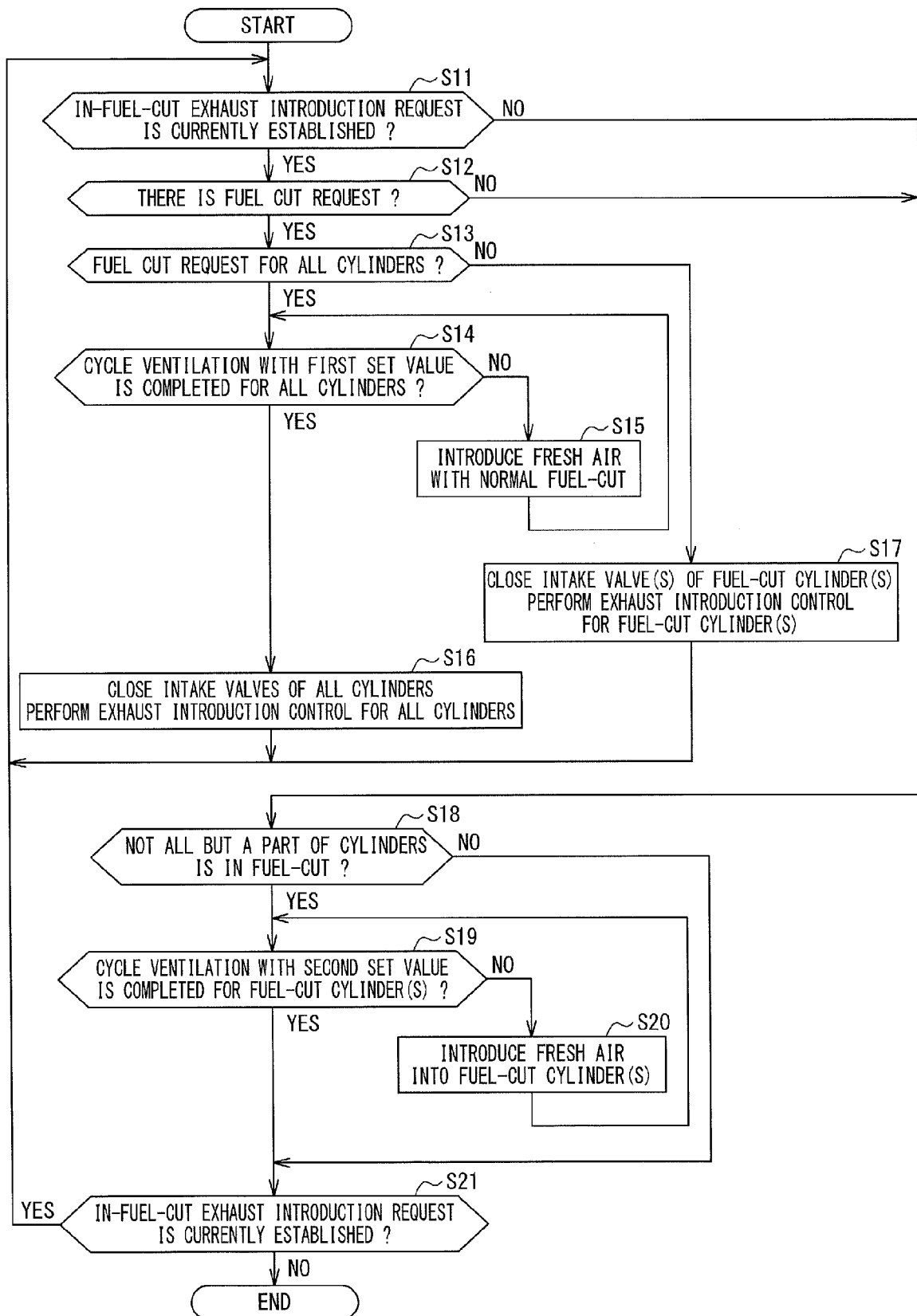


FIG. 3



REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

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