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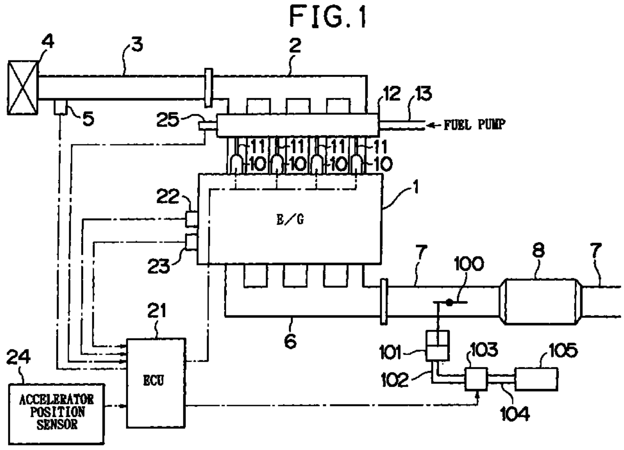
(54) **Control apparatus for internal combustion engine**

(57) Fuel injection amount correcting means (21) for correcting a fuel injection amount in accordance with a change in engine load caused by activation or deactivation of an exhaust throttle valve (100) is provided. Fluctuations of engine rotational speed at the time of deactivation of the exhaust throttle valve (100) are detected, and the timing for fuel correction performed by the fuel injection amount correcting means (21) is changed based on the detected fluctuations of engine rotational speed.

FIG.1



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Description

BACKGROUND OF THE INVENTION

1. Field of the Invention

[0001] The present invention relates to a control apparatus for an internal combustion engine that is equipped with an exhaust throttle mechanism for adjusting a cross section of an exhaust gas passage in an exhaust system.

2. Description of the Related Art

[0002] In an internal combustion engine that is installed in a motor vehicle or the like, there is known a technology wherein an exhaust throttle valve is provided and activated so as to reduce a cross section of an exhaust passage, enhance a back pressure acting on the internal combustion engine, and increase a load applied to the internal combustion engine.

[0003] According to the aforementioned technology, it is possible to produce the effect of what is called exhaust braking wherein the exhaust throttle valve is activated during deceleration of the vehicle so as to enhance a load of the internal combustion engine, reduce an engine rotational speed and restrict rotating movements of a driven wheel coupled to the internal combustion engine.

[0004] Further, according to the aforementioned technology, the exhaust throttle valve is activated, for example, during movement of the vehicle in cold condition of the internal combustion engine so as to increase an engine load. In accordance with the increase in engine load, the fuel injection amount is increased, whereby the amount of work of the internal combustion engine is increased and the heat generation amount of the internal combustion engine is increased. Thus, it becomes possible to promote warm-up of the internal combustion engine and improve heating performance. Additionally it becomes possible to improve heating capability by keeping a high temperature around the exhaust port because of a temperature increase in the exhaust gas discharged from the internal combustion engine and reducing heat radiation from the cooling system. It is, therefore, also possible to perform regeneration of a DPF (Diesel Particulate Filter), warming-up of a catalyst and the like.

[0005] While the exhaust throttle valve is in operation, if the engine rotational speed or engine load becomes greater than a predetermined value in response to depression of an accelerator pedal by the driver, the exhaust throttle valve is deactivated and control for increasing a fuel injection amount associated with exhaust throttle control is also canceled. However, there needs to be a certain length of time from a timing when an instruction to open the exhaust throttle valve is output to a timing when the exhaust throttle valve actually opens such that the pressure starts decreasing. Therefore, the valve-opening timing of the exhaust throttle valve may not coincide with the timing when the fuel injection amount is changed.

[0006] For example, if the fuel injection amount changes too early with respect to the opening of the exhaust throttle valve, the engine rotational speed fluctuates repeatedly, that is, the engine rotational speed decreases temporarily, then increases and decreases again. Conversely, if the fuel injection amount changes too late with respect to the opening of the exhaust throttle valve, the engine rotational speed fluctuates repeatedly, that is, the engine rotational speed increases temporarily, then decreases and increases again.

[0007] The aforementioned phenomenon indicates that a discrepancy between the valve-opening timing of the exhaust throttle valve and the timing when the fuel injection amount changes may induce engine rotational fluctuations, thus deteriorating driveability.

[0008] In order to solve such a problem, Japanese Patent Application Laid-Open No. HEI 5-149176 proposes a fuel injection amount control apparatus for a diesel engine. In this fuel injection amount control apparatus, it is assumed that the period from start of deactivation of the exhaust throttle valve to actual completion of the opening of the exhaust throttle valve is constant. The upper limit value of the fuel injection amount is reduced by a predetermined value at the time of deactivation of the exhaust throttle valve, and then, the upper limit value is gradually increased to a normal value within a certain length of time. In this manner, this fuel injection amount control apparatus is designed to prevent driveability from deteriorating due to a change in net torque.

[0009] It is to be noted herein that the operation time for the exhaust throttle valve changes due to age-based deterioration of components such as the exhaust throttle valve, an actuator for driving the exhaust throttle valve and the like. Hence, in the aforementioned fuel injection control apparatus, if the operation time for the exhaust throttle valve changes, there is generated a discrepancy between the valve-opening timing of the exhaust throttle valve and the timing when the fuel injection amount changes. Thereby fluctuations of torque are induced and driveability is adversely affected.

[0010] Further, the heat environment of the throttle valve changes. In other words, while the exhaust throttle valve is in operation, the throttle valve is exposed, in the vicinity of a rotational shaft portion thereof, to high-temperature exhaust gas that has been compressed. Therefore, the shaft portion is thermally expanded and thus deformed. As a result, there may be caused a change in clearance of a shaft sliding portion, in friction coefficient or in length of operation time during open-close movements.

SUMMARY OF THE INVENTION

[0011] The present invention has been made in consideration of the above-mentioned problems. In an internal combustion engine that is equipped with an exhaust throttle valve in an exhaust system, the present invention aims at providing a technology for suitably performing fuel injection control regardless of a possible change in operation time of the exhaust throttle valve resulting from age-based deterioration, a heat environment or the like, thus inhibiting generation of torque fluctuations, and preventing deterioration of driveability.

[0012] In order to solve the aforementioned problems, the present invention has taken the following measures. That is, the control apparatus for the internal combustion engine according to the present invention has an exhaust throttle valve that is disposed in an exhaust passage of the internal combustion engine and reduces a cross section of an exhaust passage so as to increase a load of the internal combustion engine, and fuel injection amount correcting means for correcting a fuel injection amount in accordance with an amount of change in engine load caused by the exhaust throttle valve. This control apparatus is characterized by comprising rotational fluctuations detecting means for detecting fluctuations of engine rotational speed during operation of the exhaust throttle valve, and fuel injection correction timing changing means for changing a timing for fuel correction performed by the fuel injection amount correcting means based on the fluctuations of engine rotational speed detected by the rotational fluctuations detecting means.

[0013] In the thus-constructed control apparatus, at the time of activation or deactivation of the exhaust throttle valve, the fuel injection amount correcting means corrects a fuel injection amount in accordance with an amount of change in engine load. In the meantime, the engine rotational fluctuations detecting means detects fluctuations of engine rotational speed of the internal combustion engine.

[0014] For example, a reference will be made to the case where the exhaust throttle valve is deactivated (the exhaust throttle valve is shifted from its closed state to its completely open state) and where the fuel injection amount correcting means cancels fuel injection amount increase correction correspondingly. In this case, if the engine rotational fluctuations detecting means detects fluctuations where the engine rotational speed decreases temporarily, then increases and decreases again, the fuel injection correction timing changing means judges that the timing for canceling fuel injection amount increase correction is too early with respect to the opening movement of the exhaust throttle valve, and thus retards the timing for canceling the fuel injection amount increase correction.

[0015] A reference will now be made to the case where the exhaust throttle valve is deactivated and where the fuel injection amount increase correction is canceled correspondingly. In this case, if the engine rotational fluctuations detecting means detects fluctuations where the engine rotational speed increases temporarily, then decreases and increases again, the fuel injection correction timing changing means judges that the timing for canceling fuel injection amount increase correction is too late with respect to the opening movement of the exhaust throttle valve, and thus advances the timing for canceling the fuel injection amount increase correction.

[0016] Thus, since the fuel injection correction timing changing means changes a timing for correcting fuel injection amount based on fluctuations of engine rotational speed, the valve-opening timing of the exhaust throttle valve is inhibited from deviating from the timing for correcting fuel injection amount. Consequently, the engine rotational speed and the engine torque are inhibited from fluctuating.

[0017] The amount of change in fuel injection correction timing determined by the fuel injection correction timing changing means may be either a fixed value or a variable value that is adjusted in accordance with the magnitude or degree of fluctuations.

BRIEF DESCRIPTION OF THE DRAWINGS

[0018]

Fig. 1 schematically shows the structure of an internal combustion engine to which a control apparatus according to the present invention is applied.

Fig. 2 shows engine rotational fluctuations in the case where the timing for opening an exhaust throttle valve has been retarded with respect to the timing for canceling fuel injection amount increase correction.

Fig. 3 shows engine rotational fluctuations in the case where the timing for opening the exhaust throttle valve has been advanced with respect to the timing for canceling fuel injection amount increase correction.

Fig. 4 is a flowchart showing a routine for canceling exhaust throttle control.

DESCRIPTION OF PREFERRED EMBODIMENT

[0019] A concrete embodiment of a control apparatus for an internal combustion engine according to the present invention will be described hereinafter with reference to the accompanying drawings.

[0020] Fig. 1 schematically shows the structure of the internal combustion engine to which the present invention is applied. Referring to Fig. 1, the description will be made on the assumption that an internal combustion engine 1 is a water-cooled diesel engine having a plurality of cylinders. However, it is to be noted that the present invention can also be applied to a direct-injection gasoline engine.

[0021] A fuel injection valve 10 is attached to each cylinder of the internal combustion engine 1. Each fuel injection valve 10 has an injection hole that is so formed as to face a combustion chamber (not shown) of each cylinder, so that fuel can directly be injected into the combustion chamber. The fuel injection valve 10 communicates with an accumulator chamber (common rail) 12 through a fuel distribution pipe 11, and the common rail 12 communicates with a fuel pump (not shown) through a fuel passage 13.

[0022] In the thus-constructed fuel injection system, fuel that has been discharged from the fuel pump is supplied to the common rail 12 through the fuel passage 13. The fuel is accumulated in the common rail 12 until it reaches a predetermined pressure. The accumulated fuel is fed to the fuel injection valve 10 through the fuel distribution pipe 11. Upon opening of the fuel injection valve 10, the accumulated fuel is injected into combustion chambers of respective cylinders.

[0023] An intake branch pipe 2 is connected to the internal combustion engine 1, and respective branches of the intake branch pipe 2 communicate with the combustion chambers of the respective cylinders through intake ports (not shown). The intake branch pipe 2 is connected to an intake pipe 3, which is connected to an air cleaner box 4 in which an air filter is installed.

[0024] In the thus-constructed intake system, after fresh air that has flown into the air cleaner box 4 is cleared of dust and refuse by the air filter, it is introduced into the intake branch pipe 2 through the intake pipe 3 and then distributed to the combustion chambers of the respective cylinders through the respective branches of the intake branch pipe 2. The intake air that has been distributed to the respective combustion chambers is compressed during a compression stroke and caused to burn with the fuel injected from the aforementioned fuel injection valve 10 acting as an ignition source.

[0025] An exhaust branch pipe 6 is connected to the internal combustion engine 1, and respective branches of the exhaust branch pipe 6 communicate with the combustion chambers of the respective cylinders through an exhaust port (not shown). The exhaust branch pipe 6 is connected to an exhaust pipe 7, which is connected on its downstream side to a muffler (not shown). A catalytic device 8, which purifies noxious gaseous components contained in exhaust gas such as NOx, unburnt HC and the like, is disposed such that the exhaust pipe 7 extends across the catalytic device 8.

[0026] In the thus-constructed exhaust system, gas that has been caused to burn in the respective cylinders of the internal combustion engine 1 is discharged into the exhaust pipe 7 through the exhaust branch pipe 6. After the exhaust gas that has been discharged into the exhaust pipe 7 is cleared of noxious gaseous components contained therein, it is discharged into the atmosphere through the muffler.

[0027] An exhaust throttle valve 100 for reducing a flow rate of exhaust gas in the exhaust pipe 7 is attached to the exhaust pipe 7 at a location upstream of the catalytic device 8. An actuator 101 of a diaphragm type is attached to the exhaust throttle valve 100 through a link mechanism or the like. The actuator 101 is connected to a vacuum switching valve (VSV) 103 through a first negative pressure passage 102. The VSV 103 is connected to a vacuum pump 105 through a second negative pressure passage 104.

[0028] In the thus-constructed exhaust throttle mechanism, the exhaust throttle valve 100 is normally kept completely open by an urging force of a spring (not shown) that is installed in the actuator 101. In a predetermined state of the internal combustion engine 1 following cold start thereof, the VSV 103 is turned on, which makes the first negative pressure passage 102 and the second negative pressure passage 104 communicate with each other. Then, the negative pressure generated in the vacuum pump 105 is applied to the actuator 101 through the first and second negative pressure passages 102, 104, so that the actuator 100 drives the exhaust throttle valve 100 in a valve-closing direction against an urging force of the spring.

[0029] If the exhaust throttle valve 100 is driven in the valve-closing direction, an exhaust flow passage in the exhaust pipe 7 is narrowed, and the exhaust pressure in the exhaust pipe 7 upstream of the exhaust throttle valve 100 rises. This exhaust pressure serves as what is called a back pressure that prevents pistons (not shown) of cylinders in an exhaust stroke from moving upwards. As a result, the load of the internal combustion engine 1 increases. At this moment, if the fuel injection amount is increased in accordance with the increase in load, the amount of work of the internal combustion engine 1 increases. In accordance therewith, the heat generation amount of the internal combustion engine 1 increases. Therefore, it is possible to improve warming-up performance of the internal combustion engine 1.

[0030] An electronic control unit (ECU: Electronic Control Unit) 21 for engine control is provided in combination with the internal combustion engine 1. The ECU 21 is composed of a CPU, a ROM, a RAM, an input interface circuit, an output interface circuit and the like, which are interconnected to one another by a bi-directional bus. Various sensors are connected to the input interface circuit through electric wires. The fuel injection valve 10, the VSV 103, the fuel injection pump and the like are connected to the output interface circuit through electric wires.

[0031] For example, the aforementioned various sensors include an air flow meter 5 that is attached to the intake pipe 3, a crank position sensor 22 and a coolant temperature sensor 23 that are attached to the internal combustion engine 1, an accelerator position sensor 24 that is attached to an accelerator pedal (not shown) or to an accelerator lever or the like operating in cooperation with the accelerator pedal, a common rail pressure sensor 25 that is attached to the common rail 12, and the like.

[0032] The air flow meter 5 is a sensor that outputs an electric signal corresponding to a mass of intake air flowing inside the intake pipe 3. The crank position sensor 22 outputs a pulse signal every time a crank shaft (not shown) of the internal combustion engine 1 rotates by a predetermined angle. By measuring a time interval at which the crank position sensor 22 outputs pulse signals, it becomes possible to detect a rotational speed of the internal combustion engine 1. The coolant temperature sensor 23 outputs an electric signal corresponding to a temperature of coolant flowing inside a water jacket (not shown) that is formed in the internal combustion engine 1. The accelerator position sensor 24 outputs an electric signal corresponding to a depression amount of the accelerator pedal. The common rail pressure sensor 25 outputs an electric signal corresponding to a fuel pressure in the common rail 12.

[0033] The ECU 21 determines an operational state of the internal combustion engine 1 based on output signal values of the aforementioned various sensors, performs fuel injection control based on the result of determination, and performs exhaust throttle control, which constitutes the gist of the present invention.

[0034] For example, during the fuel injection control, output signals of the air flow meter 5, the crank position sensor 22, the accelerator position sensor 24 and the common rail pressure sensor 25 are inputted to the ECU 21.

[0035] The ECU 21 calculates a rotational speed of the internal combustion engine 1 based on a time interval at which the crank position sensor 22 outputs pulse signals, and calculates a torque to be outputted from the internal combustion engine 1, that is, an engine torque required by the driver based on an output signal of the accelerator position sensor 24. Then, the ECU 21 controls a discharge amount of the fuel pump such that an output signal value of the common rail pressure sensor 25 becomes equal to an optimal value corresponding to the engine rotational speed and the engine torque, and calculates a fuel injection amount (a fuel injection time) and a fuel injection start timing using the output signal value of the air flow meter 5, the engine rotational speed and the engine torque requirement as parameters.

[0036] Subsequently, the ECU 21 refers to an output signal value of the crank position sensor 22 (a rotational position of the crank shaft), and applies a driving current to the fuel injection valve 10 and opens it when the rotational position of the crank shaft coincides with the aforementioned fuel injection start timing. The application of the driving current to the fuel injection valve 10 is continued for a period corresponding to the aforementioned fuel injection time.

[0037] During the exhaust throttle control, output signals of the coolant temperature sensor 23 and the accelerator position sensor 24 are inputted to the ECU 21. Then, the ECU 21 determines based on the output signal of the accelerator position sensor 24 whether or not the internal combustion engine 1 is in its moving state.

[0038] If it is determined that the internal combustion engine 1 is in its moving state, the ECU 21 determines whether or not the output signal value of the coolant temperature sensor 23 is smaller than a value indicative of a predetermined temperature. If it is determined that the output signal value of the coolant temperature sensor 23 is smaller than the value indicative of the predetermined temperature, the ECU 21 judges that the internal combustion engine 1 is in its moving state in a cold condition. Then, in order to promote warm-up of the engine, the ECU 21 operates the exhaust throttle valve 100 by applying a driving current to the VSV 103 and performs fuel injection amount increase correction by controlling the fuel injection pump and the fuel injection valve 10. In this embodiment, the present invention can be applied not only to the case where the internal combustion engine is in its idling state but also to the case where the vehicle is in its running state after cold start of the internal combustion engine. In this embodiment, the heat generation amount of the internal combustion engine is increased, making it possible to perform regeneration of a DPF (Diesel Particulate Filter), warming-up of a catalyst, and the like in accordance with a temperature rise in the exhaust gas discharged from the internal combustion engine.

[0039] Thereafter, if the output signal value of the coolant temperature sensor 23 becomes equal to or greater than the value indicative of the predetermined temperature, the ECU 21 opens again the exhaust throttle valve 100 completely by stopping supplying electricity to the VSV 103, and brings the fuel injection amount back to its normal level by canceling the fuel injection amount increase correction. In this manner, the ECU 21 cancels the exhaust throttle control.

[0040] Thus, the ECU 21 realizes fuel injection amount correcting means according to the present invention.

[0041] Further, when it becomes necessary to increase an engine rotational speed or a fuel injection amount to a constant value or greater in response to depression of the accelerator pedal during operation of the exhaust throttle valve 100, the ECU 21 opens again the exhaust throttle valve 100 completely by stopping supplying electricity to the VSV 103, and changes the fuel injection amount to a fuel injection amount corresponding to the depression amount of the accelerator pedal, the engine rotational speed and the like by canceling the fuel injection amount increase correction. In this manner, the ECU 21 cancels the exhaust throttle control.

[0042] In canceling the exhaust throttle control, the valve-opening timing of the exhaust throttle valve 100 needs to be synchronized with the timing for canceling the fuel injection amount increase correction so as to prevent the engine rotational speed from fluctuating. However, there needs to be a certain length of time (exhaust throttle valve operation time) T from a timing when the VSV 103 is stopped from being supplied with electricity to a timing when the exhaust throttle valve 100 actually completes its valve-opening operation. Thus, the ECU 21 cancels the fuel injection amount increase correction in consideration of the exhaust throttle valve operation time T.

[0043] The aforementioned exhaust throttle valve operation time T is a value that has been found out theoretically or experimentally in advance and is stored in a memory (not shown) such as a ROM, a back-up RAM and the like.

[0044] The exhaust throttle valve operation time T may change depending on age-based deterioration of the VSV 103, the actuator 101 and the like, or depending on a heat environment and the like. In such a case, the valve-opening timing of the exhaust throttle valve 100 deviates from the timing for canceling the fuel injection amount increase correction, so that the engine rotational speed fluctuates.

[0045] For example, if the valve-opening timing of the exhaust throttle valve 100 has been retarded with respect to the timing for canceling the fuel injection amount increase correction, the exhaust throttle valve 100 performs its valve-opening operation after cancellation of the fuel injection amount increase correction. In this case, the engine rotational speed fluctuates repeatedly, that is, the engine rotational speed decreases temporarily, then increases and decreases again.

[0046] If the valve-opening timing of the exhaust throttle valve 100 has been advanced with respect to the timing for canceling the fuel injection amount increase correction, the fuel injection amount increase correction is canceled after the valve-opening operation of the exhaust throttle valve 100. In this case, the engine rotational speed fluctuates repeatedly, that is, the engine rotational speed increases temporarily, then decreases and increases again.

[0047] On the other hand, according to the exhaust throttle control of this embodiment, the timing for canceling the fuel injection amount increase correction is subjected to learning (or calibration) control based on engine rotational fluctuations at the time of cancellation of the exhaust throttle control.

[0048] More specifically, the ECU 21 monitors an output signal of the accelerator pedal position 24 when the exhaust throttle valve 100 is in operation. Upon detection of depression of the accelerator pedal by the driver, the ECU 21 cancels operation of the exhaust throttle valve 100 by stopping supplying electricity to the VSV 103, and cancels the fuel injection amount increase correction after the lapse of the exhaust throttle valve operation time T from the timing when the VSV 103 has been stopped from being supplied with electricity.

[0049] In this process, the ECU 21 calculates a gradient (base gradient) a of the engine rotational speed corresponding to the vehicle acceleration based on the change in the engine rotational speed, which will serve as a reference immediately after release of the instruction to open the exhaust throttle valve.

[0050] Then, every time a certain period elapses after stopping supplying electricity to the VSV 103, the ECU 21 calculates an engine rotational speed Y based on an output signal of the crank position sensor 22. By differentiating the engine rotational speed Y, the ECU 21 calculates a gradient Y' of the engine rotational speed at intervals of the certain period.

[0051] The ECU 21 then calculates a timing and an engine rotational speed when the gradient Y' of the engine rotational speed changes from a value smaller than the base gradient a to a value greater than the base gradient (a) (when the engine rotational speed shifts from a decreasing tendency to an increasing tendency), and calculates a timing and an engine rotational speed when the gradient Y' of the engine rotational speed changes from a value greater than the base gradient (a) to a value smaller than the base gradient (a) (when the engine rotational speed shifts from an increasing tendency to a decreasing tendency). Hereinafter, a point where the gradient Y' of the engine rotational speed changes across the base gradient (a) will be referred to as a fluctuation point.

[0052] Furthermore, in a two-dimensional system of time and engine rotational speed, the ECU 21 calculates a gradient (a_1) of a line connecting the fluctuation point where the gradient Y' of the engine rotational speed changes from a value smaller than the base gradient (a) to a value greater than the base gradient (a) with the fluctuation point where the gradient Y' of the engine rotational speed changes from a value greater than the base gradient (a) to a value smaller than the base gradient (a) (hereinafter referred to as a judgment line).

[0053] If the valve-opening timing of the exhaust throttle valve 100 has been retarded with respect to the timing for canceling the fuel injection amount increase correction, the engine rotational speed Y decreases temporarily, then increases and decreases again. Hence, as shown in Fig. 2, the gradient Y' of the engine rotational speed assumes a value Y'_1 smaller than the base gradient (a) while the engine rotational speed Y first decreases, assumes a value Y'_2 greater than the base gradient (a) while the engine rotational speed Y increases, and then assumes a value Y'_3 smaller than the base gradient (a) while the engine rotational speed Y decreases again.

[0054] In this case, the gradient (a_1) of the judgment line, which connects a fluctuation point S_1 where the gradient Y' of the engine rotational speed shifts from Y'_1 to Y'_2 with a fluctuation point S_2 where the gradient Y' of the engine rotational speed shifts from Y'_2 to Y'_3, is greater than the base gradient (a).

[0055] If the valve-opening timing of the exhaust throttle valve 100 has been advanced with respect to the timing for canceling the fuel injection amount increase correction, the engine rotational speed Y increases temporarily, then decreases and increases again. Hence, as shown in Fig. 3, the gradient Y' of the engine rotational speed assumes a value Y'_4 greater than the base gradient (a) while the engine rotational speed Y first increases, assumes a value Y'_5 smaller than the base gradient (a) while the engine rotational speed Y decreases, and then assumes a value Y'_6 greater than the base gradient (a) while the engine rotational speed Y increases again.

[0056] In this case, the gradient (a_1) of the judgment line, which connects a fluctuation point S_3 where the gradient Y' of the engine rotational speed shifts from Y'_4 to Y'_5 with a fluctuation point S_4 where the gradient Y' of the engine rotational speed shifts from Y'_5 to Y'_6, is smaller than the base gradient (a).

[0057] The ECU 21 compares the base gradient (a) with the gradient (a_1) of the judgment line. If the gradient (a_1) of the judgment line is greater than the base gradient (a), it can be determined that the timing for canceling the fuel injection amount increase correction is too early with respect to the valve-opening timing of the exhaust throttle valve 100. If the gradient (a_1) of the judgment line is smaller than the base gradient (a), it can be determined that the timing for canceling the fuel injection amount increase correction is too late with respect to the valve-opening timing of the exhaust throttle valve 100.

[0058] In a multi-cylinder internal combustion engine, it is difficult to completely unify combustion states in respective cylinders. Therefore, the combustion states of the cylinders are slightly different from one another, which results in slight fluctuations of the engine rotational speed. In such a case, it is necessary to distinguish between engine rotational fluctuations resulting from inconsistency of the combustion states and engine rotational fluctuations resulting from the exhaust throttle control.

[0059] For this reason, the ECU 21 establishes a permissible range ((a-d) ~ (a+d)) by adding a predetermined value (d) to the base gradient (a) and subtracting the predetermined value (d) from the base gradient (a). The ECU 21 may be designed to determine that there are no engine rotational fluctuations resulting from the exhaust throttle control, only if the difference between the base gradient (a) and the gradient (a_1) of the judgment line exceeds the predetermined value (d).

[0060] In this connection, the ECU 21 may be designed to compare the gradient Y' of the engine rotational speed with the upper permissible value (a+d) or the lower permissible value (a-d) at the time of determination of a fluctuation point.

[0061] If it is determined that the timing for canceling the fuel injection amount increase correction is too early with respect to the valve-opening timing of the exhaust throttle valve 100, the ECU 21 learns the exhaust throttle valve operation time T in an increasing manner so as to retard the timing for canceling the fuel injection amount increase correction. That is, the ECU 21 calculates a learning value TN by adding a predetermined time Δt to the exhaust throttle valve operation time T, and stores the learning value TN in the back-up RAM as a new exhaust throttle valve operation time T.

[0062] If it is determined that the timing for canceling the fuel injection amount increase correction is too late with respect to the valve-opening timing of the exhaust throttle valve 100, the ECU 21 learns the exhaust throttle valve operation time T in a decreasing manner so as to advance the timing for canceling the fuel injection amount increase correction. That is, the ECU 21 calculates a learning value TN by subtracting a predetermined time Δt from the exhaust throttle valve operation time T, and stores the learning value TN in the back-up RAM as a new exhaust throttle valve operation time T.

[0063] The aforementioned predetermined time Δt may be either a fixed value or a variable value that is adjusted in accordance with the amplitude of engine rotational fluctuations or the like.

[0064] The aforementioned new exhaust throttle valve operation time T is used in canceling the exhaust throttle control next time. As a result, when the exhaust throttle control is canceled next time, the discrepancy between the valve-opening timing of the exhaust throttle valve 100 and the timing for canceling the fuel injection amount increase correction is eliminated. Thus, the engine rotational speed and the engine torque are inhibited from fluctuating.

[0065] In this manner, the ECU 21 realizes engine rotational fluctuations detecting means and fuel injection correction timing changing means.

[0066] The operation and effect of this embodiment will be described hereinafter.

[0067] In canceling the exhaust throttle control, the ECU 21 carries out an exhaust throttle control cancellation routine as shown in Fig. 4.

[0068] Referring to the exhaust throttle control cancellation routine, in S401, the ECU 21 calculates a vehicle acceleration based on an output signal value of the accelerator position sensor 24 prior to cancellation of the exhaust throttle control, and then calculates a gradient (base gradient) (a) of the engine rotational speed corresponding to the vehicle acceleration.

[0069] In S402, the ECU 21 retrieves an exhaust throttle valve operation time T that is stored in the back-up RAM or the like.

[0070] In S403, the ECU 21 starts a processing for canceling the exhaust throttle control. That is, the ECU 21 stops supplying electricity to the VSV 103, and then cancels the fuel injection amount increase correction after the lapse of the exhaust throttle valve operation time T from the timing when the VSV 103 is stopped from being supplied with electricity.

[0071] In S404, the ECU 21 calculates an engine rotational speed Y based on an output signal of the crank position sensor 22 every time a certain period elapses from the timing when the VSV 103 is stopped from being supplied with electricity. The ECU 21 then differentiates the engine rotational speed Y and calculates a gradient Y' of the engine rotational speed at intervals of the certain period.

[0072] In S405, the ECU 21 detects a fluctuation point where the gradient Y' of the engine rotational speed changes from a value smaller than the base gradient (a) to a value greater than the base gradient (a) and a fluctuation point where the gradient Y' of the engine rotational speed changes from a value greater than the base gradient (a) to a value smaller than the base gradient (a).

[0073] In S406, the ECU 21 calculates a gradient (a_1) of the judgment line that connects the two fluctuation points detected in S404.

[0074] In S407, the ECU 21 compares the base gradient (a) calculated in S401 with the gradient (a_1) of the judgment line calculated in S406, and determines whether or not the gradient (a_1) of the judgment line is smaller than the base gradient (a).

[0075] If it is determined in S407 that the gradient (a_1) of the judgment line is not smaller than the base gradient (a), the ECU 21 proceeds to step S408 and determines whether or not the gradient (a_1) of the judgment line is greater than the base gradient (a).

[0076] If it is determined in S408 that the gradient (a_1) of the judgment line is not greater than the base gradient (a), the ECU 21 judges that the gradient (a_1) of the judgment line is equal to the base gradient (a) and that there are no engine rotational fluctuations resulting from cancellation of the exhaust throttle control. Then, the ECU 21 terminates implementation of this routine.

[0077] If it is determined in S408 that the gradient (a_1) of the judgment line is greater than the base gradient (a), the ECU 21 judges that the timing for canceling the fuel injection amount increase correction is too early with respect to the valve-opening timing of the exhaust throttle valve 100. Then, the ECU 21 proceeds to S409.

[0078] In S409, the ECU 21 learns the exhaust throttle valve operation time T in an increasing manner so as to retard the timing for canceling the fuel injection amount increase correction. That is, the ECU 21 adds a predetermined time Δt to the exhaust throttle valve operation time T and thereby calculates a learning value TN.

[0079] In S410, the ECU 21 stores the learning value TN calculated in S409 in the back-up RAM as a new exhaust throttle valve operation time T. After having carried out the processing in S410, the ECU 21 terminates implementation of this routine.

[0080] If it is determined in S407 that the gradient (a_1) of the judgment line is smaller than the base gradient (a), the ECU 21 judges that the timing for canceling the fuel injection amount increase correction is too late with respect to the valve-opening timing of the exhaust throttle valve 100. Then, the ECU 21 proceeds to S411.

[0081] In S411, the ECU 21 learns the exhaust throttle valve operation time T in a decreasing manner so as to advance the timing for canceling the fuel injection amount increase correction. That is, the ECU 21 subtracts a predetermined time Δt from the exhaust throttle valve operation time T and thereby calculates a learning value TN.

[0082] The ECU 21 then proceeds to S410 and stores the learning value TN calculated in S411 in the back-up RAM as a new exhaust throttle valve operation time T. After having carried out the processing in S410, the ECU 21 terminates implementation of this routine.

[0083] The new exhaust throttle valve operation time T (=TN) registered in the back-up RAM in S410 is used in canceling the exhaust throttle control next time.

[0084] In this manner, according to this embodiment, the exhaust throttle valve operation time T is learned based on the engine rotational fluctuation at the time of cancellation of the exhaust throttle control. Therefore, even if the exhaust throttle valve operation time T has changed due to age-based deterioration of the exhaust throttle valve 100 or the like, the discrepancy between the valve-opening timing of the exhaust throttle valve 100 and the timing for canceling the fuel injection amount increase correction can be reduced. Consequently, it becomes possible to inhibit the engine rotational speed and the engine torque from fluctuating due to the exhaust throttle control and to prevent deterioration of driveability.

[0085] In this embodiment, the timing for canceling the fuel injection amount increase correction is controlled as follows. That is, if the valve-opening timing of the exhaust throttle valve 100 has been retarded with respect to the timing for canceling the fuel injection amount increase correction, it is detected as fluctuations of engine rotational speed that the engine rotational speed decreases temporarily, then increases and decreases again. On the other hand, if the valve-opening timing of the exhaust throttle valve 100 has been advanced with respect to the fuel injection amount increase correction, it is detected as fluctuations of engine rotational speed that the engine rotational speed increases temporarily, then decreases and increases again. However, in the respective cases, it may also be possible to control a fuel injection timing by detecting fluctuations where the engine rotational speed merely decreases or increases.

[0086] Instead of controlling a timing for canceling the fuel injection amount increase correction in the case where the exhaust throttle valve 100 is opened from its completely closed state, it may also be possible to control a timing for increasing a fuel injection amount in the case where the exhaust throttle valve 100 is closed from its open state.

[0087] Fuel injection amount correcting means (21) for correcting a fuel injection amount in accordance with a change in engine load caused by activation or deactivation of an exhaust throttle valve (100) is provided.

Fluctuations of engine rotational speed at the time of deactivation of the exhaust throttle valve (100) are detected, and the timing for fuel correction performed by the fuel injection amount correcting means (21) is changed based on the detected fluctuations of engine rotational speed.

Claims

1. A control apparatus for an internal combustion engine having an exhaust throttle valve (100) that is disposed in an exhaust passage (7) of the internal combustion engine and reduces a cross section of an exhaust passage so as to increase a load of the internal combustion engine, and fuel injection amount correcting means (21) for correcting a fuel injection amount in accordance with an amount of change in engine load caused by the exhaust throttle valve (100), characterized by comprising:

    rotational fluctuations detecting means (21) for detecting fluctuations of engine rotational speed during operation of the exhaust throttle valve (100); and
    fuel injection correction timing changing means (21) for changing a timing for fuel injection amount correction performed by the fuel injection amount correcting means (21), based on the fluctuations of engine rotational speed detected by the rotational fluctuations detecting means (21).

2. The control apparatus according to claim 1, wherein:

    the timing for fuel injection amount correction is changed when the exhaust throttle valve (100) is closed from its open state.

3. The control apparatus according to claim 1, wherein:

    the timing for fuel injection amount correction is changed when the exhaust throttle valve (100) is opened from its closed state.

4. The control apparatus according to claim 1, wherein:

    the fuel injection amount is increased when the exhaust throttle valve (100) is closed from its open state; and
    a timing for correcting a fuel injection amount in a decreasing manner is changed when the exhaust throttle valve (100) is opened from its closed state.

5. The control apparatus according to any of claims 1 to 4, wherein:

    the timing for fuel injection amount correction performed by the fuel injection amount correcting means (21) is retarded if the rotational fluctuations detecting means (21) has detected fluctuations where the engine rotational speed decreases, then increases and decreases again.

6. The control apparatus according to any of claims 1 to 4, wherein:

    the timing for fuel correction performed by the fuel injection amount correcting means (21) is advanced if the engine rotational fluctuations detecting means (21) has detected fluctuations where the engine rotational speed increases, then decreases and increases again.

7. The control apparatus according to any of claims 1 to 6, wherein:

    the timing for fuel correction performed by the fuel injection amount correcting means (21) is changed in accordance with a magnitude or degree of engine rotational fluctuations.

8. The control apparatus according to any of claims 1 to 6, wherein:

    the timing for fuel correction performed by the fuel injection amount correcting means (21) is obtained by further correcting a correction timing that has already been corrected and stored in memory means and storing the correction timing in the memory means.

FIG.1

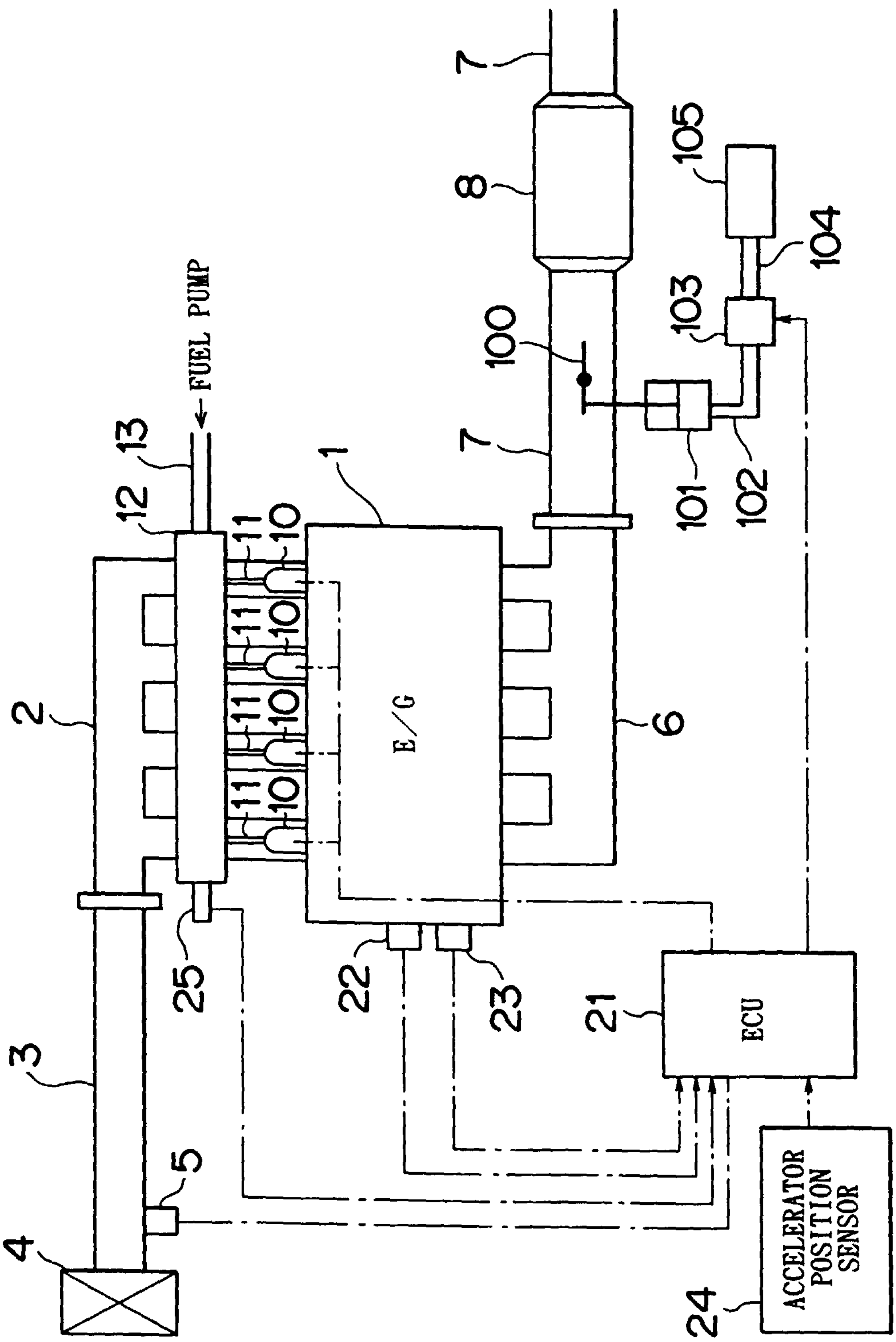

FUEL PUMP
E/G
ECU
ACCELERATOR POSITION SENSOR
1
2
3
4
5
6
7
8
10
11
12
13
21
22
23
24
25
100
101
102
103
104
105

FIG. 2

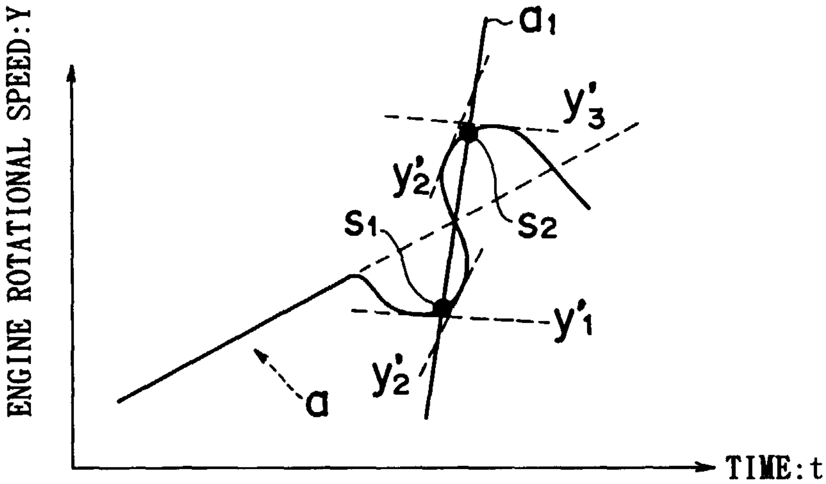

ENGINE ROTATIONAL SPEED:Y
TIME:t
a1
y'3
y'2
s1
s2
y'1
y'2
a

FIG. 3

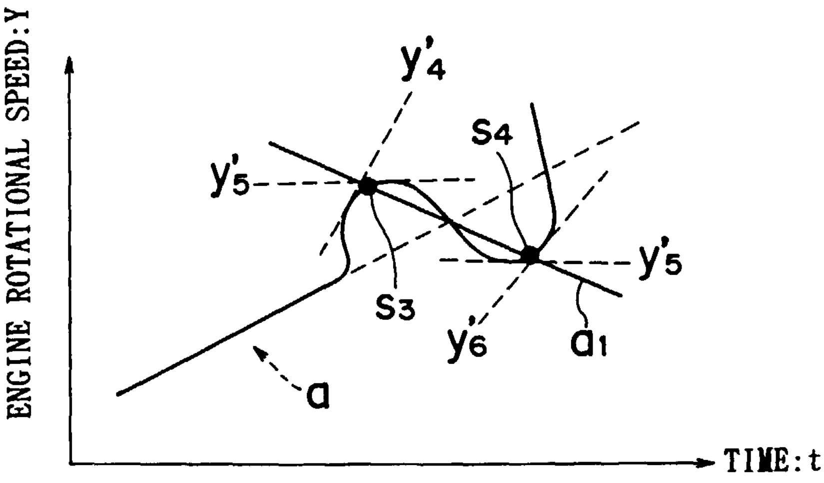
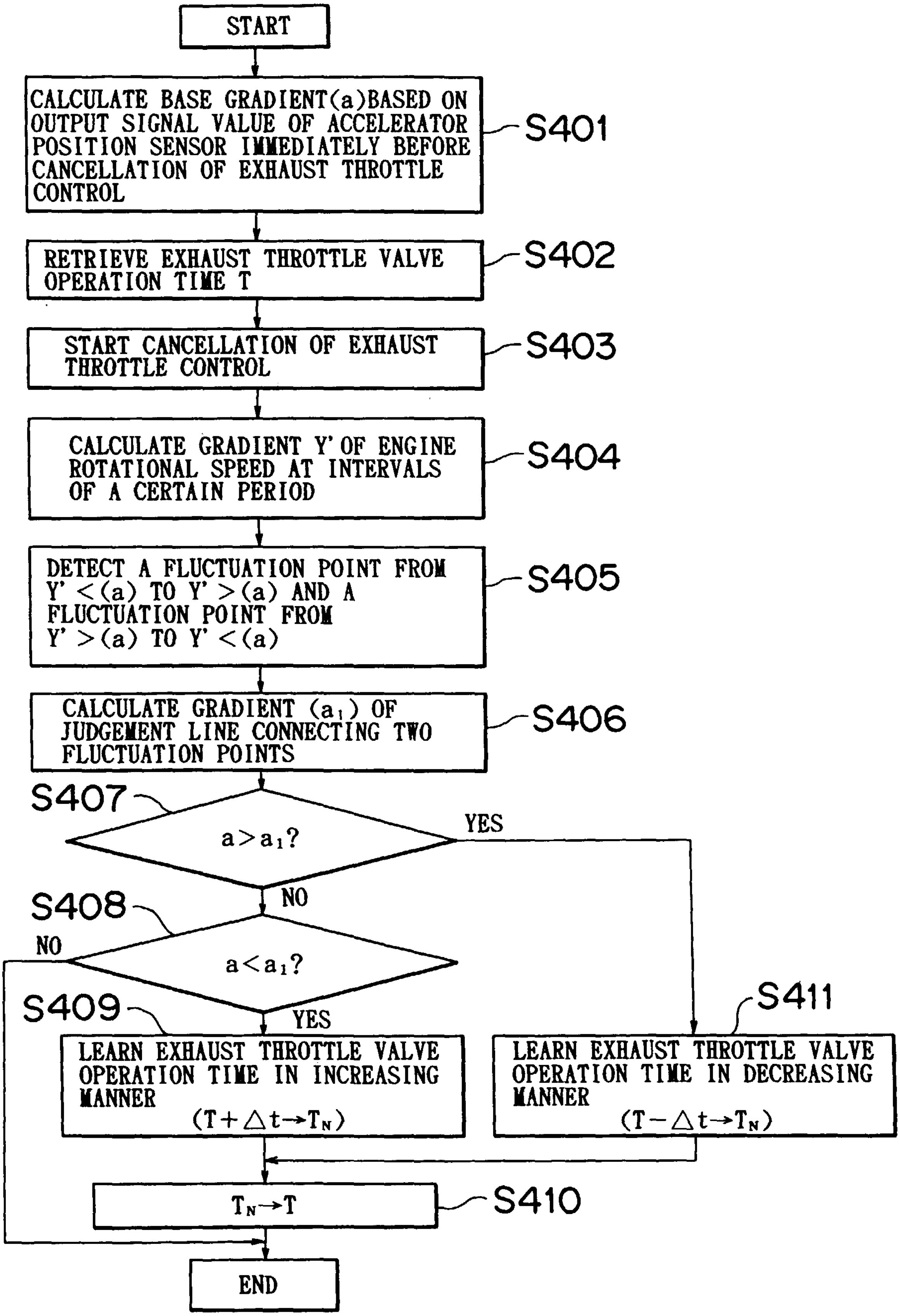

ENGINE ROTATIONAL SPEED:Y
TIME:t
y'4
s4
y'5
y'5
s3
y'6
a1
a

FIG.4


START
CALCULATE BASE GRADIENT(a)BASED ON OUTPUT SIGNAL VALUE OF ACCELERATOR POSITION SENSOR IMMEDIATELY BEFORE CANCELLATION OF EXHAUST THROTTLE CONTROL
S401
RETRIEVE EXHAUST THROTTLE VALVE OPERATION TIME T
S402
START CANCELLATION OF EXHAUST THROTTLE CONTROL
S403
CALCULATE GRADIENT Y' OF ENGINE ROTATIONAL SPEED AT INTERVALS OF A CERTAIN PERIOD
S404
DETECT A FLUCTUATION POINT FROM Y' <(a) TO Y' >(a) AND A FLUCTUATION POINT FROM Y' >(a) TO Y' <(a)
S405
CALCULATE GRADIENT (a_1) OF JUDGEMENT LINE CONNECTING TWO FLUCTUATION POINTS
S406
S407
$a > a_1$?
YES
NO
S408
NO
$a < a_1$?
YES
S409
LEARN EXHAUST THROTTLE VALVE OPERATION TIME IN INCREASING MANNER ($T + \Delta t \rightarrow T_N$)
S411
LEARN EXHAUST THROTTLE VALVE OPERATION TIME IN DECREASING MANNER ($T - \Delta t \rightarrow T_N$)
$T_N \rightarrow T$
S410
END