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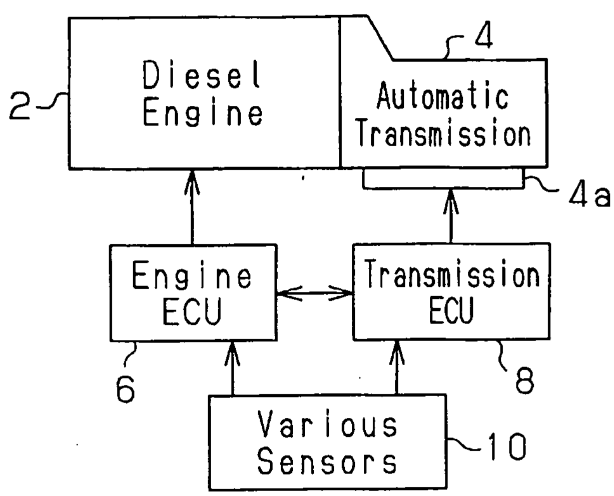
(54) Fuel supply amount controller of internal combustion engine and method for controlling the same

(57) A controller controls an amount of fuel supplied to an internal combustion engine of a vehicle. The controller restricts the fuel supply amount, which is requested for the engine, in accordance with a fail-safe limit value set correspondingly to an operation state of the engine. The controller includes changing means. When a supplemental fuel injection amount, which is requested for causing the engine to generate output torque required for purposes other than driving the vehicle, is set, the changing means causes the limit value to be equal to or to approach the supplemental fuel injection amount if the limit value is less than the supplemental fuel injection amount. Therefore, the controller corresponds to a request for causing the engine to generate output torque required for purposes other than driving the vehicle.

Fig.1



EP 1 484 492 A2

Description

BACKGROUND OF THE INVENTION

[0001] The present invention relates to a fuel supply amount controller of an internal combustion engine that regulating the fuel supply amount, thereby directly or indirectly adjusting the output torque. Specifically, the present invention relates to a fuel supply amount controller that, in accordance with a fail-safe limit value set correspondingly to an operation state of an internal combustion engine, restricts a fuel supply amount requested for the internal combustion engine. The present invention also pertains to a method for controlling the controller.

[0002] Japanese Laid-Open Patent Publication No. 2002-39004 discloses an internal combustion engine that restricts a fuel supply amount, which is a fuel injection amount, using a fail-safe limit value for performing a fail-safe procedure against errors in the computation of the fuel injection amount. Specifically, when a specific operational state, for example, a state in which an accelerator pedal is not depressed, continues for a standby period, the engine of the publication performs a procedure for restricting the fuel injection amount in accordance with a fail-safe limit value.

[0003] Therefore, even if a computed fuel injection amount becomes excessive due to garbled data in a RAM, the excessive fuel injection amount is returned to a value that corresponds to a state where the accelerator pedal is not depressed at all by releasing the accelerator pedal.

[0004] A control system is present which requests increase of a fuel injection amount in order to moderate a shock at the time of shift-down performed by an automatic transmission under deceleration. When the control system functions after a non-depressed state of an accelerator pedal continues for a standby time, even if an increase of fuel injection amount is requested for moderating a shock due to gear shifting is executed and the request is reflected on the computation of the fuel injection amount, an actual fuel injection amount is restricted correspondingly to a depression degree of the accelerator pedal with the a fail-safe limit value at the final stage for setting the fuel injection amount. Therefore, the fuel injection amount is not increased by a necessary amount and the shock due to gear shifting may not be sufficiently reduced.

SUMMARY OF THE INVENTION

[0005] Accordingly, it is an objective of the present invention to correspond to a request for causing the engine to generate output torque required for purposes other than driving the vehicle.

[0006] To achieve the above-mentioned objective, the present invention provides a controller for controlling the amount of fuel supplied to an internal combustion engine of a vehicle. Output torque of the engine is adjusted by regulating the fuel supply amount. The controller restricts the fuel supply amount, which is requested for the engine, in accordance with a fail-safe limit value set correspondingly to an operation state of the engine. The controller includes changing means. When a supplemental fuel injection amount, which is requested for causing the engine to generate output torque required for purposes other than driving the vehicle, is set, the changing means causes the limit value to be equal to or to approach the supplemental fuel injection amount if the limit value is less than the supplemental fuel injection amount.

[0007] According to another aspect of the invention, a method for controlling the amount of fuel supplied to an internal combustion engine of a vehicle is provided. Output torque of the engine is adjusted by regulating the fuel supply amount. The method includes a step of restricting the fuel supply amount, which is requested for the engine, in accordance with a fail-safe limit value set correspondingly to an operation state of the engine. The method further includes steps of setting a supplemental fuel injection amount for causing the engine to generate output torque required for purposes other than driving the vehicle; and causing the limit value to be equal to or to approach the supplemental fuel injection amount when the limit value is less than the supplemental fuel injection amount.

[0008] Other aspects and advantages of the invention will become apparent from the following description, taken in conjunction with the accompanying drawings, illustrating by way of example the principles of the invention.

BRIEF DESCRIPTION OF THE DRAWINGS

[0009] The invention, together with objects and advantages thereof, may best be understood by reference to the following description of the presently preferred embodiments together with the accompanying drawings in which:

FIG. 1 is a block diagram showing an accumulator type diesel engine, an automatic transmission, and ECUs of the engine and the transmission according to a first embodiment of the present invention;
FIG. 2 is a flowchart of a fuel injection amount control executed by the engine ECU of the first embodiment;
FIG. 3 is a graph showing a map for the control shown in FIG. 2;
FIG. 4 is a map for obtaining a supplemental amount eqEctu from a target engine speed NEt;

FIG. 5 is a map for obtaining a first limit value eqAcgurd for a pedal released state based on an engine speed NE;

FIG. 6 is a flowchart of synchronization process executed by the engine ECU of the first embodiment;

FIG. 7 is a timing chart for explaining functions and advantages of the first embodiment;

FIG. 8 is a timing chart for explaining functions and advantages of the first embodiment;

FIG. 9 is a flowchart of a fuel injection amount control executed by an engine ECU according to a second embodiment of the present invention; and

FIG. 10 is a flowchart of synchronization process executed by an engine ECU according to a third embodiment of the present invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0010] In the drawings, like numerals are used for like elements throughout.

[0011] A first embodiment according to the present invention will be described below. FIG. 1 is a block diagram showing an accumulator type diesel engine (common-rail diesel engine) 2, an automatic transmission 4, an ECU (electronic control unit) 6 of the diesel engine 2 and an ECU 8 of the transmission 4. The diesel engine 2 is mounted on a vehicle as an automobile engine.

[0012] The diesel engine 2 has cylinders the number of which is, for example, four. A fuel injection valve is set to the combustion chamber of each cylinder. Fuel raised up.to a fuel injection pressure is supplied to the fuel injection valves from a common rail. The fuel is injected into each cylinder by opening each fuel injection valve in accordance with a command by the engine ECU 6 for a valve opening period corresponding to a fuel injection amount requested for the diesel engine 2.

[0013] The diesel engine 2 and the automatic transmission 4 are provided with various sensors 10. Specifically, the diesel engine 2 is provided with an accelerator pedal depression degree sensor, an engine speed sensor, a cylinder-distinguishing sensor, a coolant temperature sensor, an intake-air temperature sensor, and fuel pressure sensor. The automatic transmission 4 is provided with a speed sensor. The engine ECU 6 detects an operation state of the diesel engine 2 and a driving state of a vehicle in accordance with outputs of various sensors 10. The engine ECU 6 exchanges commands and data with the transmission ECU 8. The engine ECU 6 controls the combustion state of the diesel engine 2 through fuel injection amount control in accordance with these commands and data.

[0014] The automatic transmission 4 is of a torque converter type, which changes speeds by controlling operations of internal rotational members, for example, various gears including a planetary gear, a clutch, and brakes. The sensors 10 include a shift position sensor and a turbine speed sensor set to the automatic transmission 4 in addition to the above configuration. The transmission ECU 8 detects a request of a driver, an internal state of the automatic transmission 4 and a driving state of a vehicle in accordance with the data on an accelerator pedal depression degree ACCP, an engine speed NE, a shift position, a turbine speed NT, and a vehicle speed V to execute vehicle speed control for the automatic transmission 4. Moreover, the transmission ECU 8 reads a coolant temperature and braking state in the data detected by the engine ECU 6. Furthermore, as described above, the transmission ECU 8 exchanges commands and data with the engine ECU 6. The transmission ECU 8 executes the speed change control of the automatic transmission 4 by switching electromagnetic valves of a hydraulic control circuit 4a in accordance with these commands and data. For example, a gear stage of the automatic transmission 4 is determined in accordance with a vehicle speed V and a fuel injection amount (or depression degree of the accelerator pedal ACCP) by using a previously stored speed-change diagram to switch electromagnetic valves of the hydraulic control circuit 4a so as to effectuate the decided gear stage.

[0015] The engine ECU 6 and the transmission ECU 8 are respectively mainly constituted by a microcomputer having a CPU, a ROM, a RAM, a backup RAM, a timer counter, an input interface, and an output interface.

[0016] Then, in the case of this embodiment, the fuel injection amount control is described among controls to be executed by the engine ECU 6. FIG. 2 shows a flowchart of the process. This control is executed as an interrupt at every constant crank angle (every explosion stroke). A step in the flowchart corresponding to each process is shown by the letter S.

[0017] When the fuel injection amount control is started, a base injection amount eqBase is first calculated in accordance with an operation state of the diesel engine 2 by the above sensors 10 (S102). The base injection amount eqBase is set by correcting a reference injection amount, that is, a governor injection amount eqgov obtained from the engine speed NE and depression degree of the accelerator pedal ACCP in accordance with a map for reference pattern data shown in FIG. 3. For example, when a load such as air conditioner load is generated on the governor injection amount eqgov, a fuel injection amount correction corresponding to the load or a correction according to learned value obtained at the time of idling speed control (ISC) is executed. Moreover, a correction is executed in which a fuel injection amount requested at the time of shift-down (described below), that is, a supplemental fuel injection amount eqEctu is used as the base injection amount eqBase. The base injection amount eqBase is calculated by executing the above various corrections.

[0018] Then, as shown in the following expression 1, an injection amount before final restriction, that is, a prefinal injection amount eqPreFinc is calculated (S104).

$$eqPreFinc \leftarrow MIN\ (eqBase,\ eqFull) \quad \text{[Expression 1]}$$

[0019] As shown in FIG. 3, the maximum injection amount eqFull is a value for setting the upper limit of a fuel injection amount to be set correspondingly to the engine speed NE in accordance with the synchronization process (synchronization) to be described later. MIN () denotes an operator for extracting a minimum value out of numerals enclosed by parentheses.
[0020] Therefore, the upper limit of the base injection amount eqBase is restricted in accordance with the expression 1 and set as the prefinal injection amount eqPreFinc.
[0021] Then, it is determined whether a standby time elapses while the depression degree of the accelerator pedal ACCP is equal to [0], that is, an accelerator pedal is released (S106). When an accelerator pedal is completely released, it is possible to estimate that a driver performs a deceleration operation. However, the changing speed of the base injection amount eqBase is restricted to prevent a shock, for example a deceleration shock from occurring due to sudden reduction of a fuel injection amount through a pedal operation. Therefore, even if a deceleration operation is performed by a driver, a deceleration shock may occur when suddenly decreasing a fuel injection amount by immediately adding a new restriction to the fuel injection amount. Therefore, a standby time is set for the determination in step S106.
[0022] When the standby time does not elapse under an accelerator pedal released state (NO in step 106), the value of the prefinal injection amount eqPreFinc is set to a final fuel injection amount (final injection amount) eqFinc (S108) and the process is temporarily ended. Thus, when the final injection amount eqFinc is set, valve-opening control for the fuel injection valves is executed by the engine ECU 6 so that the amount of fuel equivalent to the final injection amount eqFinc is injected into the combustion chamber of the diesel engine 2.
[0023] When the standby time elapses under the accelerator pedal released state (YES in S106), it is determined whether the supplemental amount eqEctu is set as a requested fuel injection amount (S110). The supplemental amount eqEctu is a requested fuel injection amount set in a synchronization process (described later). That is, the supplemental amount eqEctu is a fuel injection amount to be increased that is set as a request value at the timing in a shift-down fuel amount increasing period after increase of a fuel injection amount is requested at the time of shift-down by the transmission ECU 8. The supplemental amount eqEctu is a fuel injection amount set to prevent a deceleration shock at the time of shift-down. Specifically, the supplemental amount eqEctu is set in accordance with the target engine speed NEt set correspondingly to shift-down control in accordance with the map shown in FIG. 4.
[0024] In this case, when the supplemental amount eqEctu is not set (NO in S110), the final injection amount eqFinc is calculated in accordance with the following expression 2 (S112) and the process is temporarily ended.

$$eqFinc \leftarrow MIN\ (eqAcgurd,\ eqPreFinc) \quad \text{[Expresssion 2]}$$

[0025] A fuel-injection-amount limit value when the accelerator pedal is released, that is, a first limit value eqAcgurd is a fail-safe limit value for preventing an excessive fuel amount from being injected when a standby time elapses under the accelerator pedal released state. Specifically, the first limit value eqAcgurd is set in accordance with the engine speed NE by using the map shown in FIG. 5. The first limit value eqAcgurd is set to 0 (mm^3/stroke) or less in order to cut fuel at the engine high-speed side. Thereby, the upper limit of the prefinal injection amount eqPreFinc is restricted in accordance with the first limit value eqAcgurd and set as the final injection amount eqFinc.
[0026] Therefore, as shown in FIG. 7, the accelerator pedal is released at a high engine speed at t0 and also after a standby time elapses at t1, a state in which the final injection amount eqFinc is limited continues at the first limit value eqAcgurd while the supplemental amount eqEctu is not set. FIG. 7 shows a state in which the prefinal injection amount eqPreFinc exceeds the first limit value eqAcgurd due to any reason at t2. However, the final injection amount eqFinc does not exceed the value of the first limit value eqAcgurd.
[0027] However, when the supplemental amount eqEctu is set (YES in S110), the final injection amount eqFinc is calculated in accordance with the following expression 3 (S114) and the process is temporarily ended.

$$eqFinc \leftarrow MIN\ (MAX(eqAcgurd,\ eqEctu),\ eqPreFinc \quad \text{[Expression 3]}$$

[0028] MAX () denotes an operator for extracting a maximum value out of numerals enclosed by parentheses.
[0029] Therefore, the prefinal injection amount eqPreFinc is restricted by greater one of the supplemental amount

eqEctu and first limit value eqAcgurd and set as the final injection amount eqFinc.

[0030] In this case, as shown by the timing chart in FIG. 8, after the engine speed NE rises, the accelerator pedal is released (ACCP=0) at t10, and the standby time elapses at t11, the state is kept as described for the above expression 2 while the supplemental amount eqEctu is not set. That is, the final injection amount eqFinc is limited by the first limit value eqAcgurd.

[0031] However, when the supplemental amount eqEctu, which is greater than the first limit value eqAcgurd, is set for shift-down at t12, the final injection amount eqFinc is limited by the supplemental amount eqEctu in accordance with the above expression 3. Therefore, it is possible to increase a fuel amount so as to prevent a deceleration shock at the time of shift-down.

[0032] This state is continued during the fuel amount increase period necessary for request realization and then, the supplemental amount eqEctu returns to an unset state at t13. Therefore, the final injection amount eqFinc is limited by the first limit value egAcgurd again as described for the expression 2.

[0033] FIG. 6 shows the synchronization process for setting the maximum injection amount eqFull and supplemental amount eqEctu. The process is repeatedly executed in the engine ECU 6 at a short-time period. When the process is started, the maximum injection amount eqFull is first obtained in accordance with the engine speed NE from a maximum injection amount eqFull map shown by an alternate long and short dash line by superimposing the map in FIG. 3 (S202). Then, it is determined whether a fuel amount increase request is generated at the time of shift-down by the transmission ECU 8 (S204). When the fuel amount increase request is not generated (NO in S204), the supplemental amount eqEctu is cleared, that is, an unset state is set (S208) and the process is temporarily ended.

[0034] When the fuel amount increase request is generated at the time of shift-down (YES in S204), then it is determined whether the request is generated within a fuel amount increase period at the time of shift-down (S206). The fuel amount increase period is a period in which it is necessary to restrain a shock at the time of shift-down by increasing a torque during a speed change, which is set in accordance with, for example, the depression degree of the accelerator pedal ACCP, the vehicle speed V, the turbine speed NT, or the shift state.

[0035] In this case, when the request is not generated in the fuel amount increase period (NO in S206), the process is temporarily ended without setting the supplemental amount eqEctu (S208).

[0036] However, when the request is generated in the shift-down fuel amount increase period t12 to t13 in FIG. 8 (YES in S206), the supplemental amount eqEctu is set in accordance with the target engine speed NEt by using the above-described map in FIG. 4 (S210). By setting the supplemental amount eqEctu, the supplemental amount eqEctu is set to the base injection amount eqBase in step S102 of the fuel injection amount control process (FIG. 2). Moreover, when YES is determined in step S110, a fail-safe limit value is raised to the supplemental amount eqEctu in step S114. Therefore, the engine ECU 6 executes fuel injection according to the supplemental amount eqEctu.

[0037] In the above configuration, steps S204 to S210 of the synchronization process (FIG. 6) correspond to the process by a system for setting a requested fuel supply amount for output torques other than the torque for driving the vehicle. Steps S110 and S114 of the fuel injection amount control process (FIG. 2) correspond to the process by fail-safe limit-value changing means.

[0038] The above first embodiment has the following advantage.

[0039] (1) When the supplemental amount eqEctu is set (YES in S110 in FIG. 2), the first limit value eqAcgurd is compared with the supplemental amount eqEctu by the engine ECU 6. Then, when eqAcgurd is smaller than eqEctu, the supplemental amount eqEctu is set as a limit value instead of the first limit value eqAcgurd (S114). Therefore, when a control system for preventing a shock at the time of shift-down requires the supplemental amount eqEctu, the supplemental amount eqEctu is realized.

[0040] Thus, it is possible to supply a fuel amount requested by the control system for setting a requested fuel supply amount for output torques other than the torque for driving the vehicle and effectively prevent a speed change shock.

[0041] When the control system for preventing a shock at the time of shift-down does not require the supplemental amount eqEctu (NO in S110), the supplemental amount eqEctu is not used as a limit value but the final injection amount eqFinc is limited by the sufficiently small first limit value eqAcgurd (S112). Therefore, no problem occurs in fail safe.

[0042] A second embodiment of the present invention will now be described. The second embodiment executes a fuel injection amount control process in FIG. 9 instead of the fuel injection amount control process (FIG. 2) by the fist embodiment. Other configurations are the same as those of the first embodiment. The process in FIG. 9 sets a new accelerator released shift-down fuel injection amount limit value, that is, a second limit value eqKgurd when setting the supplemental amount eqEctu and uses the second limit value eqKgurd as a fail-safe limit value at the time of shift-down.

[0043] The processes in steps S302 to S312 in FIG. 9 are the same as the processes in steps S102 to S112 in FIG. 2. However, the processes (S314 to S318) when the supplemental amount eqEctu is set (YES in S310) are different from the case of the first embodiment.

[0044] That is, when YES is determined in step S310, it is determined whether eqAcgurd is smaller than eqEctu (S314). In this case, when eqAcgurd is equal to or greater than eqEctu, it is not necessary to change first limit value eqAcgurd. Therefore, the final injection amount eqFinc is calculated in accordance with the expression 2 described for the first embodiment (S312). Therefore, the final injection amount eqFinc is limited by the first limit value eqAcgurd.

[0045] However, when eqAcgurd is smaller than eqEctu (YES in S314), the second limit value eqKgurd is calculated in accordance with the following expression 4 (S316).

$$eqkgurd \leftarrow eqAcgurd + Deq \qquad \text{[Expression 4]}$$

[0046] In this expression, a limit value increase amount Deq is set as shown in the following expression 5.

$$Deq \leftarrow (eqEctu - eqAcgurd) \times k \qquad \text{[Expression 5]}$$

[0047] In this expression, the coefficient k ranges between 0 and 1 (both excluded) and it serves as a coefficient for setting the second limit value eqKgurd so as to meet the inequality eqAcgurd<eqKgurd<eqEctu. For example, k is set to 0.5.

[0048] Although the second limit value eqKgurd thus obtained is smaller than the supplemental amount eqEctu, it is set to a value greater than the first limit value eqAcgurd.

[0049] Then, as shown in the following expression 6, the final injection amount eqFinc is calculated (S318).

$$eqFinc \leftarrow MIN\ (eqKgurd, eqPreFinc) \qquad \text{[Expression 6]}$$

[0050] Thus, the prefinal injection amount eqPreFinc is restricted by the second limit value eqKgurd in accordance with the expression 6 and set as the final injection amount eqFinc.

[0051] In the above configuration, steps S310, S314, S316, and S318 of the fuel injection amount control process (FIG. 9) correspond to the process by fail-safe limit-value change means.

[0052] The above-described second embodiment has the following advantage.

[0053] (2) When the supplemental amount eqEctu is set (YES in S310 in FIG. 9), the first limit value eqAcgurd is compared with the supplemental amount eqEctu (S314). When eqAcgurd is smaller than eqEctu (YES in S314), the second limit value eqKgurd, which is closer to the supplemental amount eqEctu than the first limit value eqAcgurd is to the supplemental amount eqEctu, is set as a limit value (S316).

[0054] Therefore, when the control system for preventing a speed change shock at the time of shift-down requires the supplemental amount eqEctu, a fuel injection amount can be realized which is closer to the supplemental amount eqEctu than the first limit value eqAcgurd. Therefore, it is possible to restrain a speed change shock.

[0055] The shift-down fuel amount increase period determined in step S206 of the synchronization process (FIG. 6) does not always accurately coincide with a period in which a speed change shock actually occurs but a time lag may occur between the both periods. Thereby, the supplemental amount eqEctu may be set to the base injection amount eqBase in the period in which it is actually unnecessary to increase a fuel amount for the shift-down.

[0056] In this case, according to the second embodiment, the final injection amount eqFinc does not increase up to the supplemental amount eqEctu, but the second limit value eqKgurd becomes the upper limit. Therefore, it is possible to restrain a fuel injection amount for the above time lag.

[0057] When the control system for preventing a shock at the time of shift-down does not require the supplemental amount eqEctu (NO in S310) or eqAcgurd is equal to or greater than eqEctu (NO in S314), the second limit value eqKgurd is not used as a limit value. Therefore, the final injection amount eqFinc is limited by the sufficiently small first limit value eqAcgurd (S312). Therefore, no problem occurs in fail safe.

[0058] A third embodiment of the present invention will now be described. This embodiment executes the synchronization process in FIG. 10 instead of the synchronization process by the first embodiment (FIG. 6). Other configurations are the same as those of the first embodiment. The process in FIG. 10 limits the supplemental amount eqEctu by a shift-down injection amount limit value, that is, a maximum supplemental amount eqEctuMax.

[0059] The processes in steps S402 to S408 in FIG. 10 are the same as the processes in steps S202 to S208 in FIG. 6. However, the processes (S410 to S416) in the shift-down fuel amount increase period (YES in S406) are different from that of the first embodiment.

[0060] That is, when YES is determined in step S406, pre-restriction shift-down injection amount eqPreEctu is set in accordance with the target engine speed NEt by using a map same as the map in FIG. 4 described for the first embodiment (S410). Then, it is determined whether the eqPreEctu is equal to or smaller than the maximum supplemental amount eqEctuMax to which the maximum fuel injection amount required to prevent a shock at the time of shift-down is set (S412).

[0061] When eqPreEctu is equal to or smaller than eqEctuMax (YES in S412), the value of the eqPreEctu is directly set to the supplemental amount eqEctu (S414) and the process is temporarily ended. Therefore, the above case is the same as the case of obtaining the supplemental amount eqEctu in accordance with the map in FIG. 4 in the first embodiment.

[0062] However, when eqPreEctu is greater than eqEctuMax (NO in S412), it is discovered that an excessive value is set to the eqPreEctu due to any cause such as an error of data communication between the engine ECU 6 and the transmission ECU 8. Therefore, the maximum supplemental amount eqEctuMax is set to the supplemental amount eqEctu (S416) and the process is temporarily ended. Thus, the supplemental amount eqEctu is limited by the maximum supplemental amount eqEctuMax. Thereby, the supplemental amount eqEctu does not become excessive also in step S114 of the fuel injection amount control process (FIG. 2). Then, an excessive value is not set to the final injection amount eqFinc.

[0063] In the above configuration, the maximum supplemental amount eqEctuMax corresponds to the maximum requested fuel injection amount and steps S404 to S416 of the synchronization process (FIG. 10) correspond to processes by the control system for setting a requested fuel supply amount for output torques other than the torque for driving the vehicle.

[0064] The above third embodiment has the following advantages.

[0065] (3) Advantage same as the advantage (1) of the first embodiment.

[0066] (4) Since the supplemental amount eqEctu is also limited and prevented from taking an excessive value, the fail-safe in the fuel injection amount control process (FIG. 2) becomes more reliable.

[0067] The invention may be embodied in the following forms.

[0068] The third embodiment is an example in which the synchronization process in FIG. 10 is combined with the fuel injection amount control process in FIG. 2. However, it is also allowed to combine the synchronization process in FIG. 10 with the fuel injection amount control process in FIG. 9. Thereby, both advantages of the second and third embodiments are obtained.

[0069] In the above embodiments, a fuel supply system uses a common-rail-type diesel engine. However, it is also allowed to use a diesel engine using the distribution-type, in-line-type, or other-type fuel injection pump. Moreover, the present invention may be applied to an engine other than a diesel engine. For example, the present invention may be applied to an in-cylinder-injection-type gasoline engine when controlling the engine by adjusting a gasoline injection amount at the time of stratified charge combustion.

[0070] For a gasoline engine, it is allowed to calculate a fuel injection amount in accordance with the depression degree of the accelerator pedal ACCP and the engine speed NE, as the case of the above-described map in FIG. 3. Moreover, it is allowed to calculate a fuel injection amount in accordance with the engine speed NE and a throttle opening degree, which is the opening degree of a throttle valve.

[0071] As described above, the output torque of an internal combustion engine is directly adjusted by adjusting a fuel supply amount. Moreover, in the case of a gasoline engine, it is allowed to calculate a fuel injection amount in accordance with an intake air amount and the engine speed NE. That is, it is allowed to adjust indirectly the output torque of an internal combustion engine by adjusting a fuel supply amount.

[0072] The present examples and embodiments are to be considered as illustrative and not restrictive and the invention is not to be limited to the details given herein, but may be modified within the scope and equivalence of the appended claims.

Claims

1. A controller for controlling the amount of fuel supplied to an internal combustion engine of a vehicle, wherein output torque of the engine is adjusted by regulating the fuel supply amount, wherein the controller restricts the fuel supply amount, which is requested for the engine, in accordance with a fail-safe limit value set correspondingly to an operation state of the engine, the controller being **characterized by**:

    changing means, wherein, when.a supplemental fuel injection amount, which is requested for causing the engine to generate output torque required for purposes other than driving the vehicle, is set, the changing means causes the limit value to be equal to or to approach the supplemental fuel injection amount if the limit value is less than the supplemental fuel injection amount.

2. The controller according to claim 1, **characterized in that** the changing means uses the supplemental fuel injection amount as the limit value.

3. The controller according to claim 1 or 2, **characterized in that** the limit value is set when a state in which an

accelerator pedal of the vehicle is not depressed continues for a predetermined standby period.

4. The controller according to claim 1 or 2, **characterized in that** the limit value is set when a state in which a throttle valve of the vehicle is fully closed continues for a predetermined standby period.

5. The controller according to any one of claims 1 to 4, **characterized in that** the supplemental fuel injection amount is limited to be no more than a predetermined maximum value.

6. The controller according to any one of claims 1 to 5, **characterized in that** the supplemental fuel injection amount is set for moderating a shock, which is produced when gear shifting of an automatic transmission of the vehicle is executed.

7. The controller according to any one of claims 1 to 6, **characterized in that** the supplemental fuel injection amount is set for moderating a deceleration shock, which is produced when gear shifting of an automatic transmission of the vehicle is executed.

8. A method for controlling the amount of fuel supplied to an internal combustion engine of a vehicle, wherein output torque of the engine is adjusted by regulating the fuel supply amount, the method being **characterized by**:

restricting the fuel supply amount, which is requested for the engine, in accordance with a fail-safe limit value set correspondingly to an operation state of the engine;
setting a supplemental fuel injection amount for causing the engine to generate output torque required for purposes other than driving the vehicle; and
causing the limit value to be equal to or to approach the supplemental fuel injection amount when the limit value is less than the supplemental fuel injection amount.

9. The method according to claim 8, **characterized in that** the limit value is set when a state in which an accelerator pedal of the vehicle is not depressed or a state in which a throttle valve of the vehicle is fully closed continues for a predetermined standby period.

10. The method according to claim 8 or 9, **characterized in that** the supplemental fuel injection amount is set for moderating a shock, which is produced when gear shifting of an automatic transmission of the vehicle is executed.

Fig.1

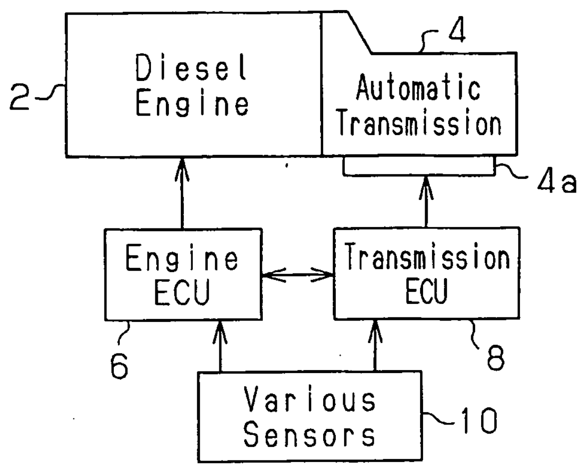

Diesel Engine
2
4
Automatic Transmission
4a
Engine ECU
6
Transmission ECU
8
Various Sensors
10

Fig.2

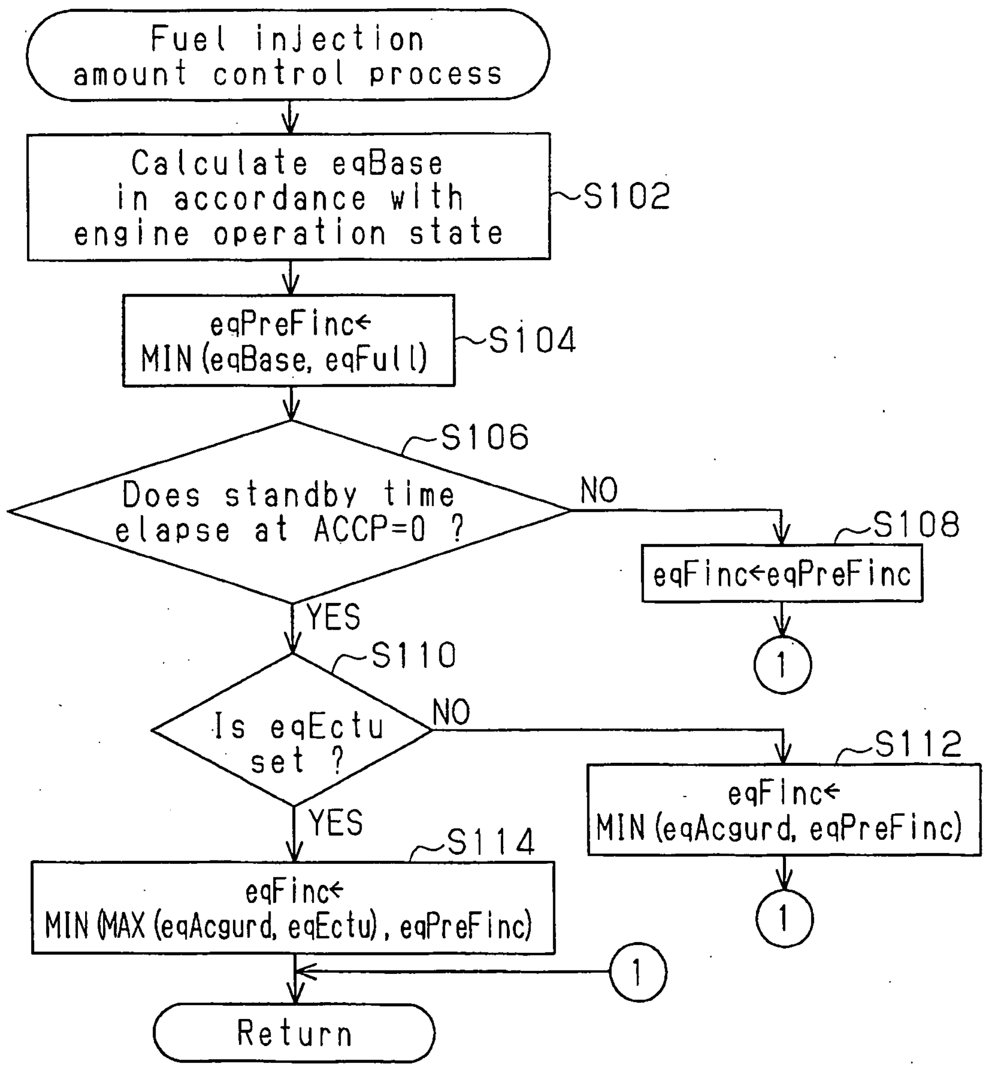

Fuel injection amount control process
Calculate eqBase in accordance with engine operation state
S102
eqPreFinc← MIN (eqBase, eqFull)
S104
Does standby time elapse at ACCP=0 ?
S106
NO
S108
eqFinc←eqPreFinc
1
YES
Is eqEctu set ?
S110
NO
S112
eqFinc← MIN (eqAcgurd, eqPreFinc)
1
YES
S114
eqFinc← MIN (MAX (eqAcgurd, eqEctu), eqPreFinc)
1
Return

Fig.3

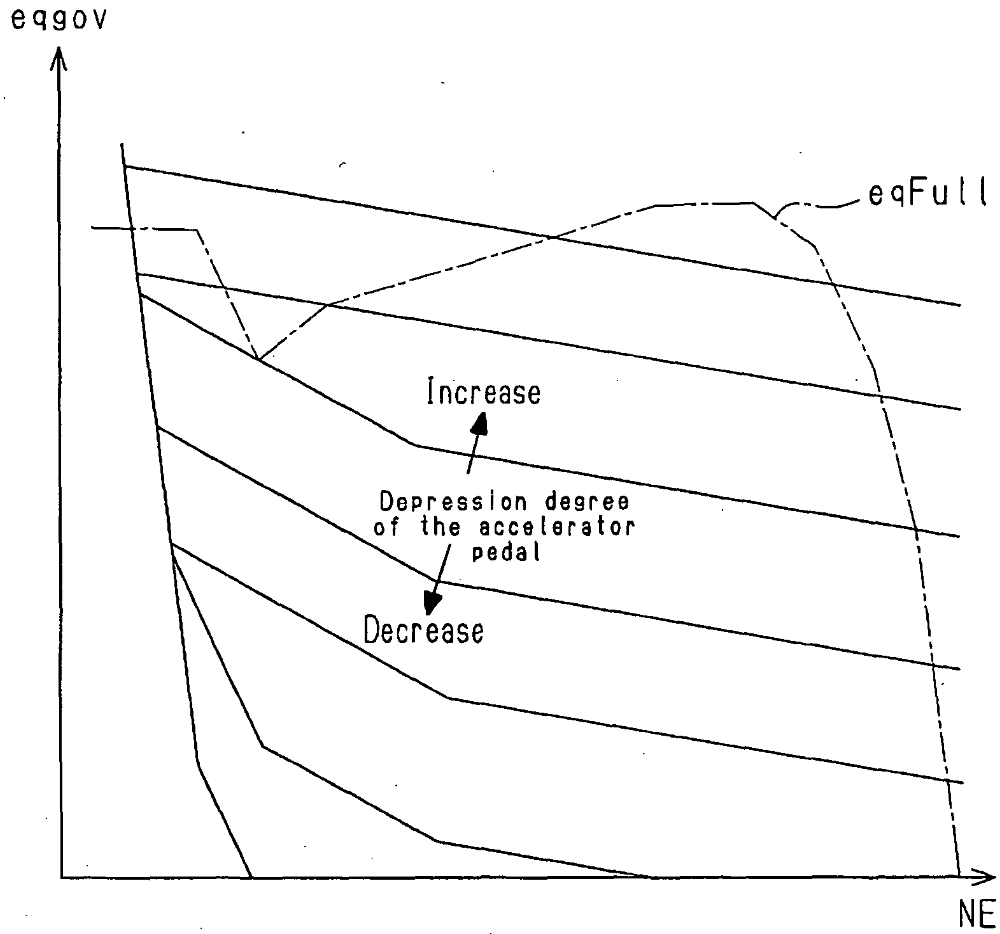

eqgov
eqFull
Increase
Depression degree
of the accelerator
pedal
Decrease
NE

Fig.4

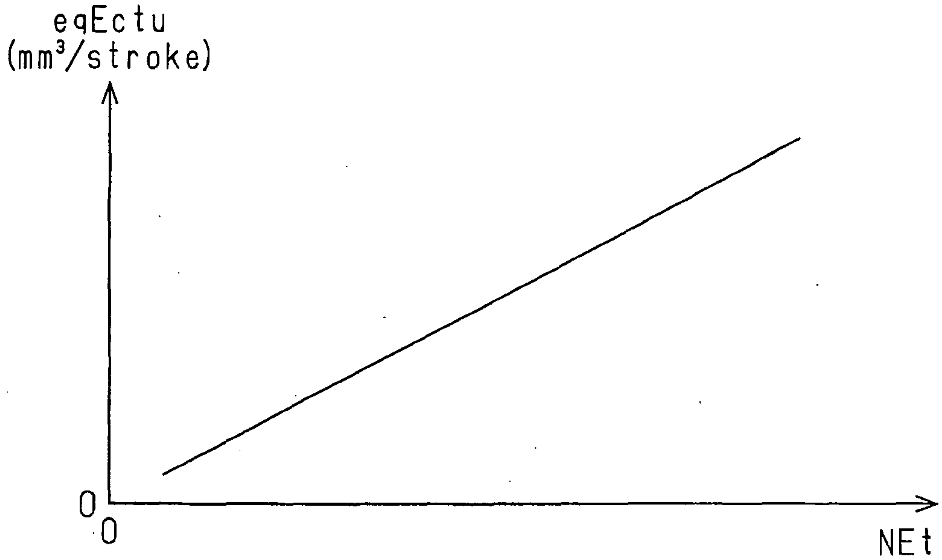


Fig.5

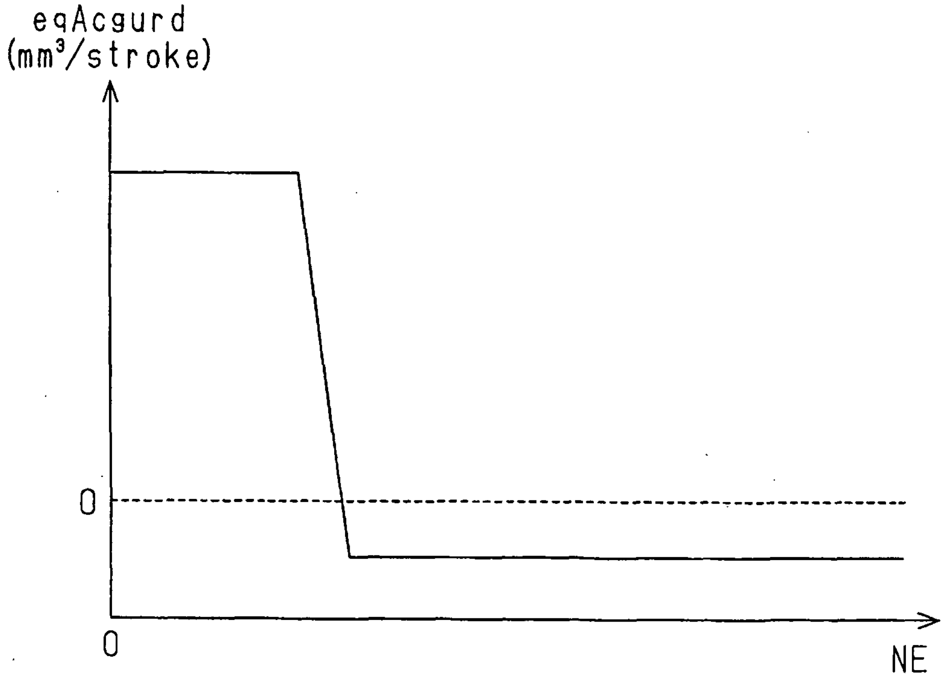


Fig.6

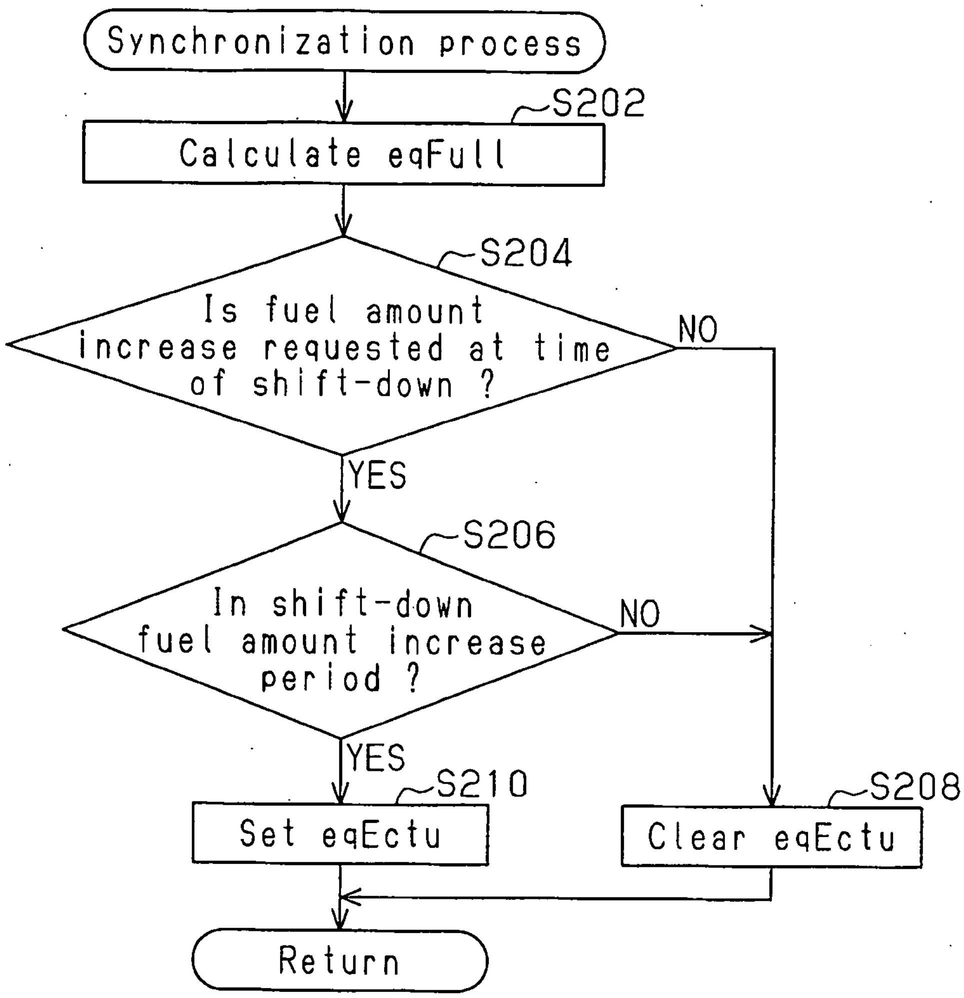

Synchronization process
S202
Calculate eqFull
S204
Is fuel amount increase requested at time of shift-down ?
NO
YES
S206
In shift-down fuel amount increase period ?
NO
YES
S210
Set eqEctu
S208
Clear eqEctu
Return

Fig.7

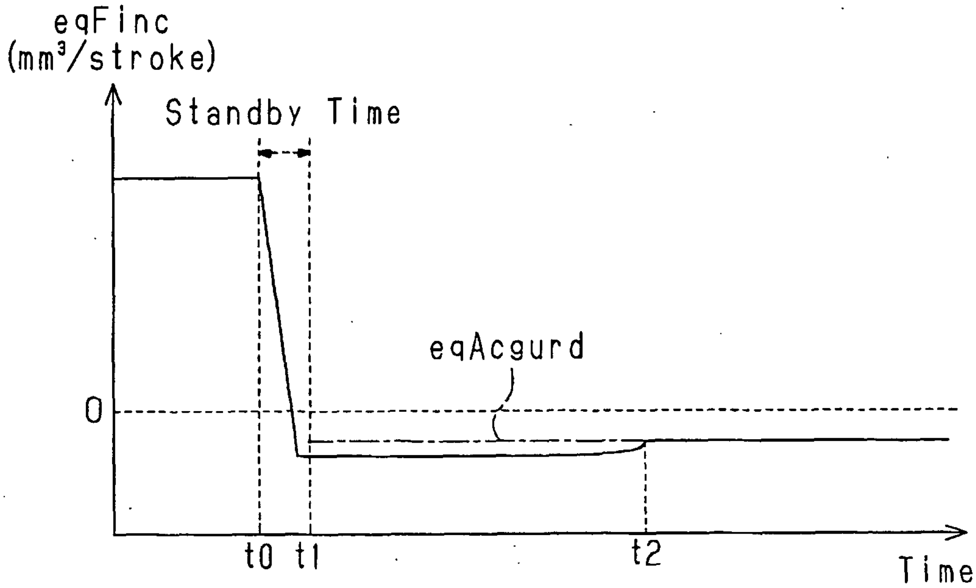

eqFinc
(mm³/stroke)
Standby Time
eqAcgurd
0
t0 t1
t2
Time

Fig.8

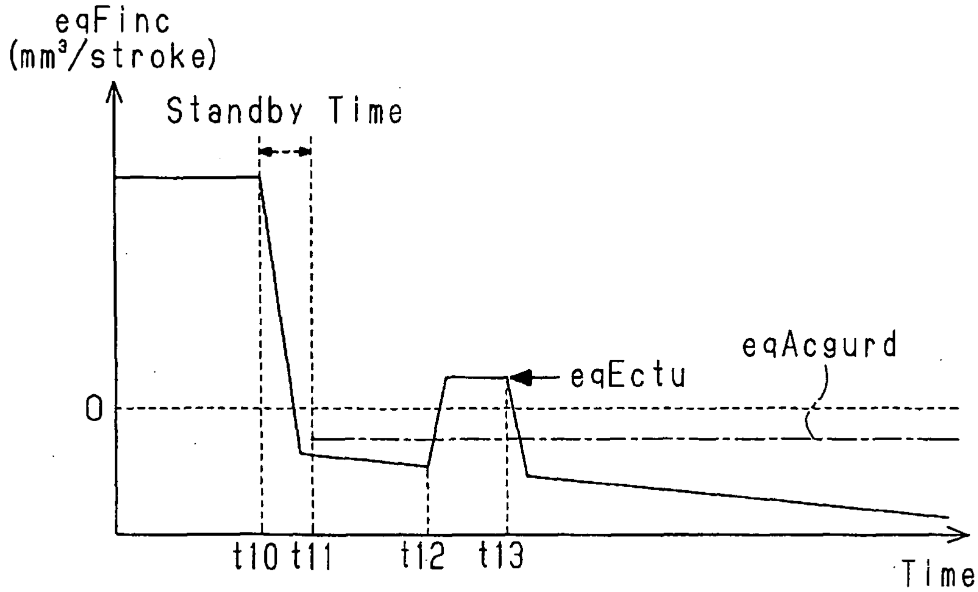

eqFinc
(mm³/stroke)
Standby Time
eqEctu
eqAcgurd
0
t10 t11
t12 t13
Time

Fig.9

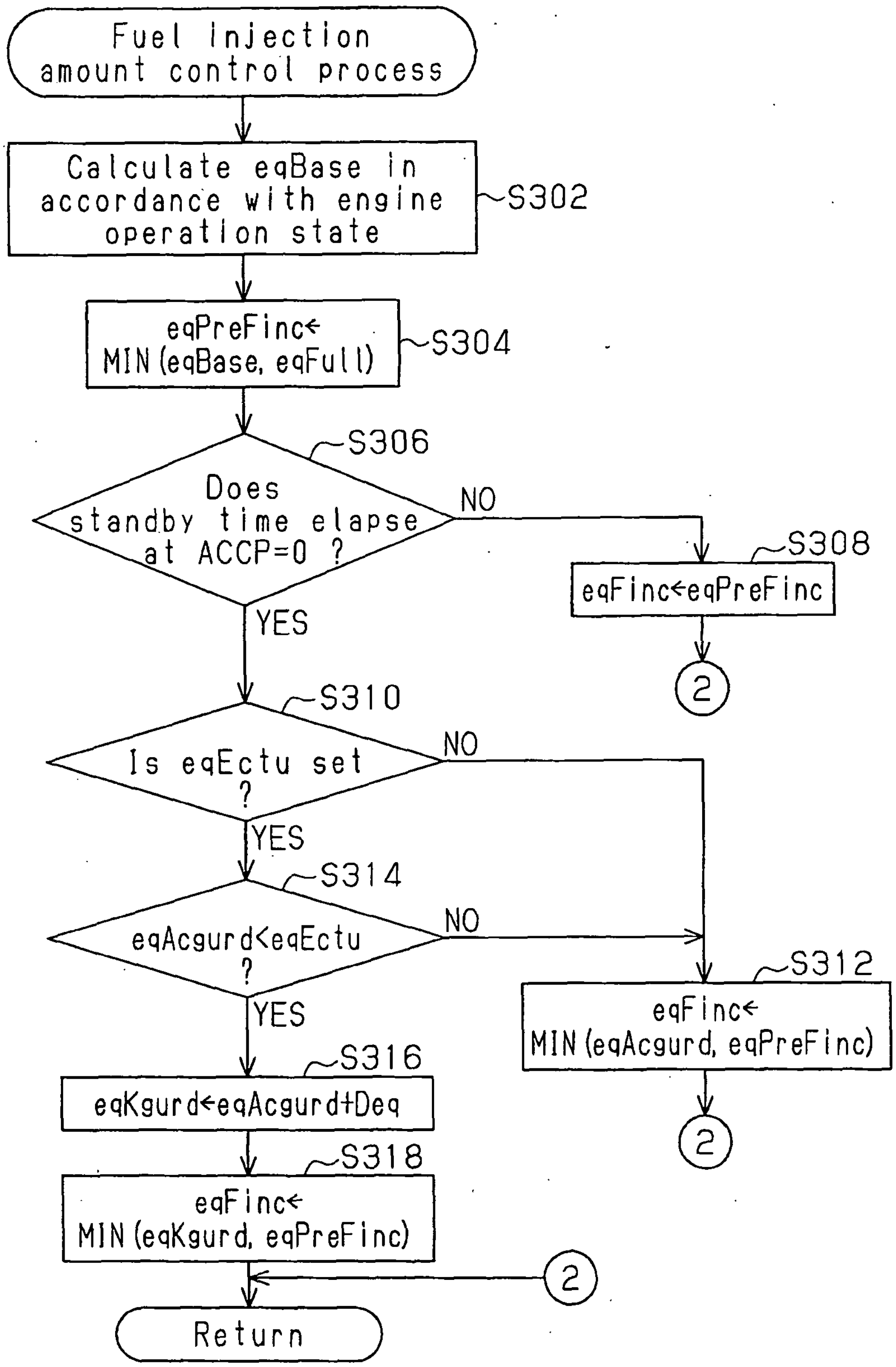
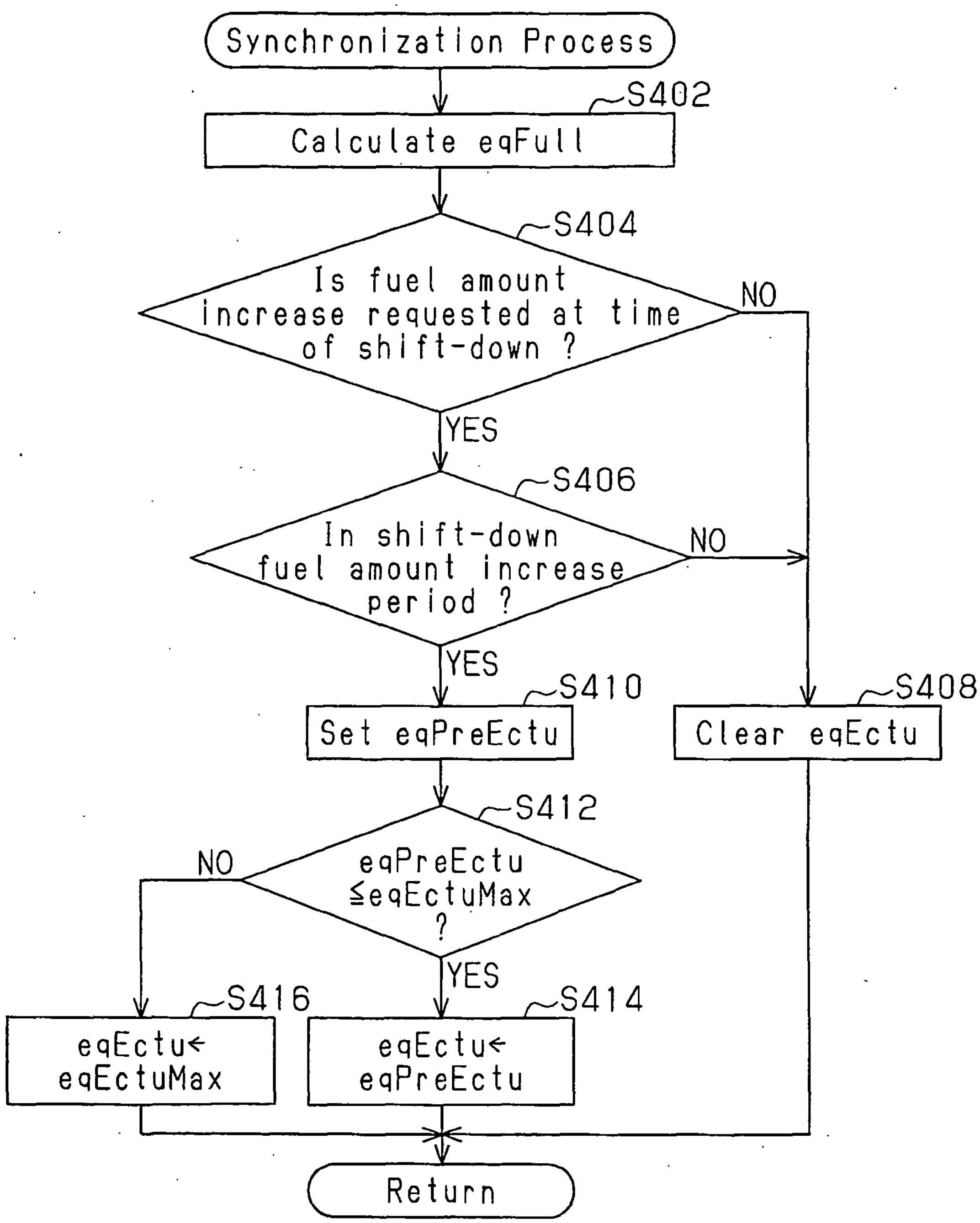

Fuel injection amount control process
Calculate eqBase in accordance with engine operation state
S302
eqPreFinc← MIN (eqBase, eqFull)
S304
Does standby time elapse at ACCP=0 ?
S306
NO
YES
eqFinc←eqPreFinc
S308
2
Is eqEctu set ?
S310
NO
YES
eqAcgurd<eqEctu ?
S314
NO
YES
eqFinc← MIN (eqAcgurd, eqPreFinc)
S312
2
eqKgurd←eqAcgurd+Deq
S316
eqFinc← MIN (eqKgurd, eqPreFinc)
S318
2
Return

Fig.10


Synchronization Process
S402
Calculate eqFull
S404
Is fuel amount increase requested at time of shift-down ?
NO
YES
S406
In shift-down fuel amount increase period ?
NO
YES
S410
Set eqPreEctu
S408
Clear eqEctu
S412
eqPreEctu ≦eqEctuMax ?
NO
YES
S416
eqEctu← eqEctuMax
S414
eqEctu← eqPreEctu
Return