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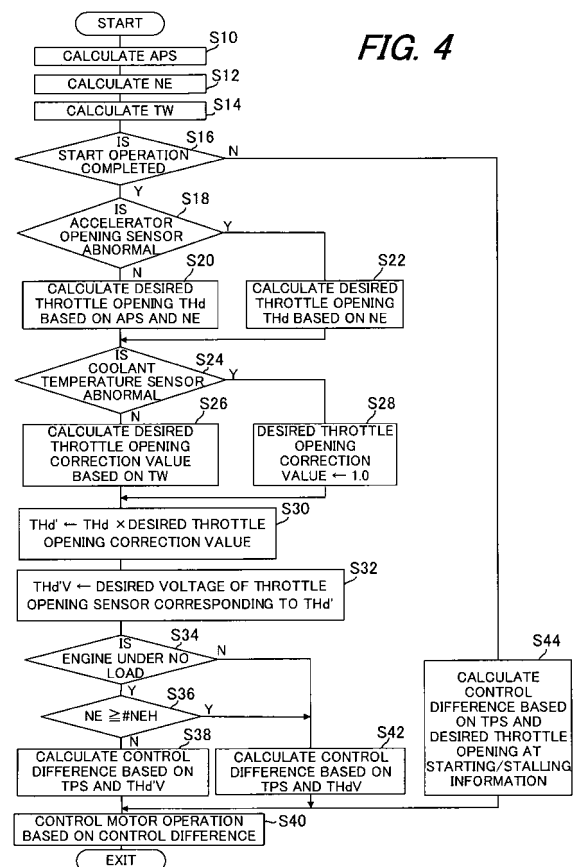
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(54) **Control system for internal combustion engine**

(57) In a system for controlling an internal combustion engine (12) mounted on a vehicle (10) and having an actuator (44) that drives a throttle valve (24) installed in an intake pipe (23) of the engine and an accelerator (17) installed to be operable by the operator, it is configured to comprise an actuator controller that controls the operation of the actuator such that the detected actual opening of the throttle valve becomes the desired opening calculated based on accelerator opening APS and engine speed NE, when the engine is determined to be under no load. With this, it becomes possible to prevent a stall of the engine without impairing operating feel of the operator even when an accelerator is rapidly opened during no load operation of the engine.



Description

BACKGROUND OF THE INVENTION

Field of the Invention

[0001] This invention relates to a control system for an internal combustion engine, particularly to a control system for an internal combustion engine that controls operation of an actuator that drives a throttle valve installed in an intake pipe of the engine (such as a single-cylinder engine) mounted on a vehicle such as a motorcycle.

Description of the Related Art

[0002] Conventionally, there have been known control systems for internal combustion engines that suppress the engine speed at relatively low level when the engine is operated under no load such as idling, thereby improving fuel efficiency. However, when a throttle valve is rapidly opened by manipulation of an accelerator by the operator (driver) in the low engine speed condition, flow rate of intake air sharply increases and it may cause a stall. Further, the stall can lead to reverse rotation of the crankshaft, resulting in damage of the engine due to the mechanical load.

[0003] In a technique proposed by, for example, Japanese Patent Publication No. Hei 6(1994)-72563, the throttle valve is driven by an actuator, i.e., utilizing the DBW (Drive By Wire) system, and when the accelerator is rapidly opened in the low engine speed range, the actuator drives the throttle valve to open slowly, thereby restraining sharp increase in air flow rate.

[0004] The above-mentioned technique is configured so that, when the engine speed is low and velocity of the accelerator manipulation is equal to or higher than a predetermined value, velocity of the throttle valve movement in the opening direction is made lowered by a certain value. As a result, a large difference between velocity of the accelerator manipulation and velocity of the throttle valve movement is produced, it makes the operator uncomfortable, and operating feel degrades. Thus the technique in the above reference is not necessarily satisfactory in terms of operating feel.

SUMMARY OF THE INVENTION

[0005] An object of this invention is therefore to overcome the foregoing drawback by providing a control system for an internal combustion engine that can prevent a stall of the engine without impairing operating feel even when an accelerator is rapidly opened during no load operation of the engine.

[0006] In order to achieve the object, this invention provides a system for controlling operation of an actuator that drives a throttle valve installed in an intake pipe of an internal combustion engine mounted on a vehicle having an accelerator installed to be operable by the oper-

ator, characterized by a throttle opening detector that detects actual opening of the throttle valve; an accelerator opening detector that detects opening of the accelerator; an engine speed detector that detects speed of the engine; a desired throttle opening calculator that calculates desired opening of the throttle valve based on the detected opening of the accelerator and the detected engine speed; a no-load condition determiner that determines whether the engine is operated under no load; and an actuator controller that controls the operation of the actuator such that the detected actual opening of the throttle valve becomes the calculated desired opening when the engine is determined to be under no load.

BRIEF DESCRIPTION OF THE DRAWINGS

[0007] The above and other objects and advantages of the invention will be more apparent from the following description and drawings in which:

FIG 1 is an overall view schematically showing a control system for an internal combustion engine according to an embodiment of this invention;

FIG 2 is a block diagram functionally showing the configuration of an engine controller shown in FIG. 1; FIG 3 is a block diagram functionally showing the configuration of a throttle valve controller shown in FIG. 1;

FIG 4 is a flowchart showing the operation of the system shown in FIG 1;

FIG 5 is a graph expressing the characteristics of desired throttle opening with respect to accelerator opening and engine speed, which is used in the processing of the flowchart of FIG 4;

FIG. 6 is a graph expressing the characteristics of a desired throttle opening correction value with respect to coolant temperature, which is used in the processing of the flowchart of FIG 4; and

FIG. 7 is a time chart for explaining the processing of the flowchart of FIG 4.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

[0008] A control system for an internal combustion engine according to a preferred embodiment of the present invention will now be explained with reference to the attached drawings.

[0009] FIG 1 is an overall view schematically showing a control system for an internal combustion engine according to an embodiment of this invention.

[0010] In FIG. 1, reference numeral 10 designates a saddle-seat vehicle, specifically a motorcycle. The motorcycle 10 is mounted with an internal combustion engine 12 and equipped with a handlebar 13 attached to the upper end of a telescopic fork (not shown) of a front wheel and other equipment. The engine 12 is a 4-cycle, single-cylinder, water-cooled gasoline engine having a

displacement of 250 cc or thereabout.

[0011] The output of the engine 12 is transformed in rotational speed by a transmission 14 and sent to a rear wheel 15 to drive the motorcycle 10. A clutch 16 is interposed between the engine 12 and transmission 14 and, when operated, makes or breaks the connection between the engine 12 and transmission 14. The transmission 14 comprises a manual transmission with six forward gear speeds.

[0012] The right end of the handlebar 13 (as viewed by the operator) is equipped with an accelerator 17, precisely an accelerator 17 constituted as a throttle grip to be operable by the operator, and with a front wheel brake lever 18 to be operable by the operator. The front wheel brake lever 18 is mechanically connected to a front wheel brake through a hydraulic cylinder (neither shown). When operated (gripped) by the operator, it operates the front wheel brake to brake the front wheel.

[0013] The left end of the handlebar 13 is equipped with a grip 19 that the operator can grip and with a clutch lever 20. The clutch lever 20 is mechanically connected to the clutch 16 through a cable (not shown). When operated (gripped) by the operator, it operates the clutch 16 to make or break, i.e., connect or disconnect, power transmission from the engine 12 to the transmission 14. A clutch switch 21 is provided near the clutch lever 20 and, when the clutch lever 20 is gripped by the operator, produces an ON signal.

[0014] A shift lever (not shown) is provided near a foot step on the lower left side of a frame, which the operator moves up and down by foot to select one gear speed (gear position or gear ratio) among the six forward gear speeds, or a neutral position. A neutral switch 22 installed near the transmission 14 produces an ON signal when the shift (gear) position is neutral.

[0015] A throttle valve 24 installed in an air intake pipe 23 (partially shown in FIG 1) of the engine 12 regulates the amount of intake air passing through the air intake pipe 23. An injector (not shown) is installed downstream of the throttle valve 24 in the air intake pipe 23 for injecting gasoline fuel into the intake air regulated by the throttle valve 24. The fuel injected by the injector mixes with intake air to form an air-fuel mixture that flows into a combustion chamber 30 when an intake valve 26 opens.

[0016] The air-fuel mixture flowing into the combustion chamber 30 is ignited to burn by a spark discharge from a spark plug 32 supplied with high voltage from an ignition coil (not shown), thereby driving a piston 34 downward in the drawing to rotate a crankshaft 36. When an exhaust valve 40 opens, the exhaust gas produced by the combustion passes through an exhaust pipe, catalyst for removing harmful components of the exhaust gas (neither shown) and the like to be discharged outside the engine 12. The crankshaft 36 and other components are housed in a crank case (not shown) and an oil pan (not shown) for receiving lubricant oil is provided at the lower portion of the crank case.

[0017] As shown in FIG. 1, the throttle valve 24 is me-

chanically separated from the accelerator (throttle grip) 17. Specifically, the throttle valve 24 is connected to an actuator or electric motor 44 through a reduction gear mechanism 42 to be driven by the operation of the motor 44. The motor 44 is constituted of a three-phase brushless DC motor having a rotor, stator and the like. The throttle valve 24 is thus operated by a DBW (Drive-By-Wire) system using the motor 44.

[0018] A hall sensor or rotor position sensor 50 having hall elements attached near the rotor is provided at the motor 44 and produces an output or signal in response to a position of the rotor. A throttle opening sensor (throttle opening detector) 52 constituted of a potentiometer is provided near the throttle valve 24 and produces an output or signal indicative of the actual opening of the throttle valve 24 (hereinafter called the "actual throttle opening") between around 0 degree and around 90 degrees.

[0019] An accelerator opening sensor (accelerator opening detector) 54 similarly constituted of a potentiometer is provided near the accelerator 17 and produces an output or signal in response to the actual opening of the accelerator 17 (more exactly, the amount of rotation of the throttle grip). The opening of the accelerator 17 is set to a value corresponding to throttle opening near 0 degree as the initial position and to throttle opening near 90 degrees at full rotation.

[0020] An intake air pressure sensor or absolute pressure sensor 56 installed at an appropriate position of the air intake pipe 23 produces an output or signal indicative of the absolute pressure in the air intake pipe 22 (engine load). A coolant temperature sensor (engine temperature detector) 60 attached to a coolant passage (not shown) of the cylinder block of the engine 12 produces an output or signal corresponding to the engine coolant temperature. A crank angle sensor (engine speed detector) 62 installed near the crankshaft 36 of the engine 12 outputs a pulse signal at a predetermined crank angle.

[0021] The motorcycle 10 is further equipped with an engine controller 64 that controls fuel injection and the like of the engine 12 and a throttle valve controller 66 that controls the operation of the throttle valve 24, precisely, the motor 44. The controllers 64, 66 are connected to a battery 72 through an ignition switch 70 to be supplied with operating power.

[0022] The engine controller 64 comprises a plurality of detection circuits electrically connected to the above-mentioned accelerator opening sensor 54 and the like for detecting sensor outputs and a microprocessor (MPU) 64a that produces an output or signal used for, based on the sensor outputs detected by the detection circuits, controlling the operation of the injector and other outputs.

[0023] As shown in FIG. 1, the output of the accelerator opening sensor 54 is inputted to the MPU 64a through an accelerator opening sensor output detection circuit (accelerator opening detector) 64b. The output of the throttle opening sensor 52 is inputted to the MPU 64a through a throttle opening sensor output detection circuit

(throttle opening detector) 64c. The MPU 64a is also inputted with the output of the intake air pressure sensor 56 through an intake air pressure sensor output detection circuit (intake air pressure detector) 64d, with the output of the coolant temperature sensor 60 through a coolant temperature sensor output detection circuit (coolant temperature detector) 64e, and with the output of the crank angle sensor 62 through a crank angle sensor output detection circuit (crank angle sensor output detector) 64f.

[0024] Further the MPU 64a is inputted with the output of the clutch switch 21 through a clutch switch output detection circuit (clutch switch output detector) 64g and with the output of the neutral switch 22 through a neutral switch output detection circuit (neutral switch output detector) 64h. Based on the outputs of the detection circuits 64b to 64h, the MPU 64a calculates accelerator opening APS and the like, and it will be explained later.

[0025] Upon turning-on of the ignition switch 70 by the operator, the battery 72 is connected to a battery voltage detection circuit (battery voltage detector) 64j through a power circuit 64i that supplies operating power to the MPU 64a. The output of the battery voltage detection circuit 64j is also sent to the MPU 64a. Based on the outputs of the battery voltage detection circuit 64j and the like, the MPU64a determines whether the battery 72 is capable of driving the motor 44, e.g., whether the voltage of the battery 72 is equal to or greater than a predetermined value, and when it is discriminated to be capable, outputs an enable signal.

[0026] On the other hand, the throttle valve controller 66 comprises a MPU 66a that produces an output or signal used for controlling the operation of the motor 44 and other outputs based on the outputs of the rotor position sensor 50 and the like. As illustrated, the MPU66a is connected to the MPU 64a of the engine controller 64 to be able to communicate each other through a CAN (Controller Area Network), specifically, connected so as to enable communication of the signals indicative of the calculated accelerator opening APS, actual throttle opening TPS and the like.

[0027] The outputs of the rotor position sensor 50 (i.e., hall sensor outputs of U-phase, V-phase and W-phase) are inputted to the MPU 66a through a rotor position sensor output detection circuit (rotor position detector) 66b. Based on the output of the rotor position sensor output detection circuit 66b, the accelerator opening APS forwarded from the MPU 64a and the like, the MPU 66a outputs signals (i.e., U-phase, V-phase and W-phase outputs) used for controlling the operation of the motor 44 to the motor drive circuit (motor-drive three-phase output controller) 66c.

[0028] The throttle valve controller 66 is further equipped with a power circuit 66d that supplies operating power from the battery 72 to the MPU 66a and motor 44 upon turning-on of the ignition switch 70, and a battery voltage detection circuit (battery voltage detector) 66e connected to the power circuit 66d to detect the voltage of the battery 72. The output of the battery voltage de-

tection circuit 66e is sent to the MPU 66a. Based on the inputted output and the like, the MPU 66a determines whether the battery 72 is capable of driving the motor 44, e.g., whether the voltage of the battery 72 is equal to or greater than a predetermined value, and when it is discriminated to be capable, outputs an enable signal.

[0029] The enable signal from the MPU 66a and the above-mentioned enable signal from the MPU 64a are sent to an AND circuit (third motor-drive enable determiner; explained later) 66f. When the two enable signals are inputted, specifically when it is discriminated in the both MPUs 64a, 66a that the battery 72 is capable of driving the motor 44, the AND circuit 66f outputs a Hi-level signal to close an enable relay 66g and supplies motor drive voltage from the power circuit 66d to the motor drive circuit 66c.

[0030] When supplied with the motor drive voltage from the power circuit 66d, i.e., when the enable relay 66g is closed, based on the outputs of the MPU 66a, the motor drive circuit 66c sends outputs to the coil (U-, V-, W-phases) of the motor 44.

[0031] The configurations of the engine controller 64 and throttle valve controller 66 are further explained with reference to FIGs. 2 and 3.

[0032] FIG 2 is a block diagram functionally showing the configuration of the engine controller 64 and FIG. 3 is a block diagram functionally showing the configuration of the throttle valve controller 66. Constituent elements shown in FIG. 1 are assigned by the same references and will not be explained. The power circuits 64i, 66d and the like shown in FIG. 1 are also omitted for ease of illustration.

[0033] First the engine controller 64 is explained. As shown in FIG 2, the output of the accelerator opening sensor 54 detected by the accelerator opening detector 64b is inputted to an accelerator opening calculator 64a1 of the MPU 64a and Analog-to-Digital converted. The A/D converted value is transformed using a suitable characteristic curve to obtain a value corresponding to a throttle opening value between about 0 degree and about 90 degrees, specifically to the accelerator opening APS (i.e., the accelerator opening APS is calculated or detected).

[0034] The output of the throttle opening sensor 52 detected by the throttle opening detector 64c is inputted to a throttle opening calculator 64a2 of the MPU 64a and Analog-to-Digital converted. The A/D converted value is transformed using a suitable characteristic curve to obtain a value corresponding to a value of the throttle valve 24 between about 0 degree and about 90 degrees, specifically to the actual throttle opening TPS (i.e., the actual throttle opening TPS is calculated or detected).

[0035] The output of the intake air pressure sensor 56 detected by the intake air pressure detector 64d is sent to an intake air pressure calculator 64a3 of the MPU 64a and Analog-to-Digital converted. The A/D converted value is transformed to intake air pressure PBA using a suitable characteristic curve (i.e., the intake air pressure PBA is calculated or detected). The output of the coolant tem-

perature sensor 60 detected by the coolant temperature detector 64e is sent to a coolant temperature calculator 64a4 of the MPU 64a and Analog-to-Digital converted. The A/D converted value is transformed to coolant temperature (engine temperature) TW using a suitable characteristic curve (i.e., the coolant temperature TW is calculated or detected).

[0036] The output of the crank angle sensor 62 detected by the crank angle sensor output detector 64f is inputted to an engine speed calculator 64a5 of the MPU 64a and counted to calculate or detect engine speed NE. The output of the clutch switch 21 detected by the clutch switch output detector 64g is inputted to a clutch condition detector 64a6 of the MPU 64a to detect or determine whether the clutch lever 20 is being grasped. The output of the neutral switch 22 detected by the neutral switch output detector 64h is sent to a neutral condition detector 64a7 of the MPU 64a to detect or determine whether the shift (gear) position is neutral.

[0037] The battery voltage detected by the battery voltage detector 64j is sent to a battery voltage calculator 64a8 and Analog-to-Digital converted. The A/D converted value is transformed to battery voltage VB using a suitable characteristic curve (i.e., the battery voltage VB is calculated or detected). The battery voltage VB calculated by the battery voltage calculator 64a8 is forwarded to a first motor-drive enable determiner 64a9 that determines whether the battery 72 or the like is capable of driving the motor 44.

[0038] The MPU 64a is further equipped with a failure determiner 64a10 that determines the presence/absence of a failure of the accelerator opening sensor 54, coolant temperature sensor 60 and the like based on the outputs of the foregoing detectors etc., a fuel/ignition controller 64a11 that controls fuel supply, ignition timing and the like based on the outputs of the detectors and the calculators, an engine operating condition transmitter 64a12 that transmits the outputs of the detectors to the MPU 66a of the throttle valve controller 66 through the CAN, and a motor operating condition receiver 64a13 that receives the outputs transmitted from the MPU 66a through the CAN.

[0039] Specifically, the failure determiner 64a10 is inputted with outputs of the accelerator opening detector 64b, throttle opening detector 64c, intake air pressure detector 64d, engine speed calculator 64a5, battery voltage calculator 64a8 and motor operating condition receiver 64a13, and based thereon, determines whether a failure (abnormality) occurs in the engine 12. A result of this determination is inputted to the first motor-drive enable determiner 64a9.

[0040] Based on the determination result of the failure determiner 64a10 and the battery voltage VB outputted from the battery voltage calculator 64a8, the first motor-drive enable determiner 64a9 determines whether the battery voltage VB is equal to or greater than a predetermined value (i.e., a value indicative of voltage capable of driving the motor 44), and when it is discriminated to

be capable, outputs an enable signal.

[0041] The fuel/ignition controller 64a11 is inputted with outputs of the accelerator opening detector 64b, throttle opening detector 64c, intake air pressure detector 64d, coolant temperature detector 64e, clutch switch output detector 64g, neutral switch output detector 64h, battery voltage calculator 64a8, failure determiner 64a10, motor operating condition receiver 64a13 and other calculators and detectors 64a1 to 64a7, and based thereon, controls fuel supply, ignition timing and the like.

[0042] The engine operating condition transmitter 64a12 is inputted with outputs of the accelerator opening detector 64b, throttle opening detector 64c, intake air pressure detector 64d, coolant temperature detector 64e, engine speed calculator 64a5, clutch condition detector 64a6 and neutral condition detector 64a7 (i.e., outputs indicating operating condition of the engine 12), and forwards them to the MPU 66a.

[0043] Next the throttle valve controller 66 is explained. As shown in FIG. 3, the MPU 66a is equipped with an engine operating condition receiver 66a1 that receives the output of the engine operating condition transmitter 64a12. Among outputs received by the engine operating condition receiver 66a1, the output of the accelerator opening detector 64b (indicated as "APS INFO" in FIG. 3) is inputted to an accelerator opening calculator 66a2 and Analog-to-Digital converted. The A/D converted value is transformed to the accelerator opening APS using a suitable characteristic curve (i.e., the accelerator opening APS is calculated or detected).

[0044] The output of the throttle opening detector 64c ("TPS INFO" in FIG. 3) received by the engine operating condition receiver 66a1 is inputted to a throttle opening calculator 66a3 and Analog-to-Digital converted. The A/D converted value is transformed to the actual throttle opening TPS using a suitable characteristic curve (i.e., the actual throttle opening TPS is calculated or detected).

[0045] The MPU 66a is equipped with a desired throttle opening calculator 66a4 for calculating desired throttle opening of the throttle valve 24. The desired throttle opening calculator 66a4 is inputted with the APS information, TPS information, output of the intake air pressure detector 64d (PBA INFO), output of the coolant temperature detector 64e (TW INFO), output of the engine speed calculator 64a5 (engine speed NE), outputs of the clutch condition detector 64a6 and neutral condition detector 64a7, actual throttle opening TPS and accelerator opening APS. The processing for calculating the desired throttle opening of the throttle valve 24 in the desired throttle opening calculator 66a4 will be explained later.

[0046] The desired throttle opening calculated by the desired throttle opening calculator 66a4 is inputted to a desired voltage calculator 66a5 and control difference calculator 66a6. The desired voltage calculator 66a5 calculates desired voltage (desired throttle opening information THd'V) of the motor 44 that is corresponding to the desired throttle opening. The control difference calculator 66a6 is inputted with, in addition to the desired

throttle opening, the calculated desired voltage of the motor 44, TPS information of the engine operating condition receiver 66a1 and actual throttle opening TPS of the throttle opening calculator 66a3, and based thereon, calculates a control difference of the motor 44.

[0047] The calculated control difference is sent to a control output calculator 66a7 that calculates a control output (e.g., excitation pattern for outputting to the U-, V- and W-phases) of the motor 44. The control output calculator 66a7 is inputted also with the output of the rotor position sensor 50 detected by the rotor position detector 66b and based on the control difference and the output of the rotor position sensor 50, calculates the control output of the motor 44.

[0048] The output of the control output calculator 66a7 is sent to a motor-drive three-phase outputter 66a8 that calculates duty ratio for PWM-driving the each of U-, V- and W-phases and produces PWM outputs. The output of the motor-drive three-phase outputter 66a8 is sent to the motor operating condition transmitter 66a9, to a motor-drive current detector 66a10 that detects motor drive current and to a motor-drive three-phase output controller 66c that controls a three-phase output used for driving the motor 44.

[0049] The motor-drive current detector 66a10 detects the motor drive current based on the output of the motor-drive three-phase outputter 66a8 and the detected motor drive current is sent to a motor drive current calculator 66a11 to calculate the motor drive current. The calculated motor drive current is inputted to a second motor-drive enable determiner 66a12 that determines whether the battery 72 or the like is capable of driving the motor 44.

[0050] The battery voltage detected by the battery voltage detector 66e is sent to a battery voltage calculator 66a13 of the MPU 66a and Analog-to-Digital converted. The A/D converted value is transformed to the battery voltage VB using a suitable characteristic curve (i.e., the battery voltage VB is calculated or detected). The output of the battery voltage detector 66e is also forwarded to a motor-drive voltage calculator 66a14 for calculating voltage for driving the motor 44.

[0051] The MPU 66a is further equipped with a fault determiner 66a15 that determines the presence/absence of a failure of the motor 44, throttle valve 24 and the like based on the outputs of the foregoing detectors and calculators etc. Specifically, the failure determiner 66a15 is inputted with the APS information, TPS information and outputs of the desired voltage calculator 66a5, control difference calculator 66a6, motor-drive current detector 66a10, battery voltage calculator 66a13, motor-drive voltage calculator 66a14 and rotor position detector 66b, and based thereon, determines whether a failure (abnormality) occurs in the motor 44, throttle valve 24 or the like. A result of this determination is inputted to the second motor-drive enable determiner 66a12.

[0052] The second motor-drive enable determiner 66a12 is inputted also with, in addition to the outputs of

the motor drive current calculator 66a11 and fault determiner 66a15, the output of the motor-drive voltage calculator 66a14. Based on the outputs, the second motor-drive enable determiner 66a12 determines whether it is capable of driving the motor 44, and when it is discriminated to be capable, outputs an enable signal.

[0053] Both the enable signals of the first and second motor-drive enable determiners 66a9, 66a12 are inputted to the third motor-drive enable determiner 66f. When inputted with the two enable signals, the third motor-drive enable determiner 66f outputs the Hi-level signal to operate the motor-drive three-phase output controller 66c. When the third motor-drive enable determiner 66f outputs the Hi-level signal, the motor-drive three-phase output controller 66c controls the operation of the motor 44 based on the output of the motor-drive three-phase outputter 66a8.

[0054] FIG. 4 is a flowchart showing the operation of the system according to this embodiment. The illustrated program is executed in the throttle valve controller 66 and the like at every predetermined interval, e.g., 10msec.

[0055] In S 10, the output of the accelerator opening sensor 54 is obtained and based thereon, the accelerator opening APS is calculated. The program proceeds to S12, in which, based on the output of the crank angle sensor 62, the engine speed NE is calculated, to S14, in which, based on the output of the coolant temperature sensor 60, the coolant temperature TW is calculated, and to S16, in which it is determined whether the engine start operation has been completed. This determination is made by checking whether the engine speed NE has reached full-firing engine speed, e.g., 1800 rpm.

[0056] When the result in S16 is YES, the program proceeds to S 18, in which it is determined whether the accelerator opening sensor 54 is abnormal. The processing of S18 is conducted by the failure determiner 64a10 of the engine controller 64. When the result in S18 is NO, i.e., it is discriminated that the accelerator opening sensor 54 is normal, the program proceeds to S20, in which, based on the accelerator opening APS and engine speed NE, the desired throttle opening THd is calculated.

[0057] Specifically, the desired throttle opening THd is calculated by retrieving the characteristic curve (mapped data) shown in FIG. 5 using the accelerator opening APS and engine speed NE. The desired throttle opening THd is set to an upper limit value that makes possible to prevent or avoid a stall, which is determined from the accelerator opening APS and engine speed NE. More specifically, as shown in FIG. 5, when the engine speed NE is relatively low, a possibility of stall occurrence due to quick opening of the throttle valve 24 is high, so the desired throttle opening THd is set to a small value regardless of the accelerator opening APS. On the other hand, when the engine speed NE is relatively high, the possibility is low, so the desired throttle opening THd is set to a value that is substantially proportional to (or follows) the accelerator opening APS.

[0058] When the result in S18 is YES, i.e., the accelerator opening sensor 54 is abnormal and the accelerator opening APS is not calculated, the program proceeds to S22, in which the desired throttle opening THd is calculated based on the engine speed NE.

[0059] Next, in S24, it is determined whether the coolant temperature sensor 60 is abnormal. The processing of S24 is conducted by the failure determiner 64a10 similarly to the step of S18. When the result in S24 is NO, i.e., it is discriminated to be normal, the program proceeds to S26, in which based on the coolant temperature TW, a desired throttle opening correction value is calculated.

[0060] Explaining the "desired throttle opening correction value," lubricant oil of the engine 12 changes in viscosity depending on the temperature of the engine 12 (e.g., coolant temperature TW). Precisely, the lubricant oil viscosity is high with low engine temperature and it lowers as the temperature rises. When the lubricant oil viscosity is high, it makes rotation performance of the crankshaft 36 or the like degrade, thereby increasing possibility of occurrence of a stall in the engine 12. Therefore, the desired throttle opening THd obtained in S20 or S22 is corrected with the desired throttle opening correction value calculated based on the engine temperature (coolant temperature TW) such that the desired throttle opening THd becomes a value that can prevent a stall further reliably.

[0061] Specifically, the desired throttle opening correction value is calculated by retrieving the characteristic curve (mapped data) shown in FIG 6. As shown in FIG. 6, the desired throttle opening correction value is a value at or below 1.0 and proportional to the coolant temperature TW, i.e., a value which increases with increasing coolant temperature TW (i.e., with decreasing viscosity of lubricant oil).

[0062] When the result in S24 is YES, since the coolant temperature TW is not obtained, the program proceeds to S28, in which the desired throttle opening correction value is set to 1.0, and to S30, in which a value obtained by multiplying the desired throttle opening THd by the desired throttle opening correction value is set to final desired throttle opening THd'. Thus the desired throttle opening THd is corrected based on the detected engine temperature (coolant temperature TW).

[0063] Next in S32, the desired voltage calculator 66a5 calculates a desired voltage of the throttle opening sensor 52 corresponding to the desired throttle opening THd' and the calculated desired voltage is set as desired throttle opening information THd'V.

[0064] The program proceeds to S34, in which it is determined whether the engine 12 is operated under no load (i.e., idling operation, a condition where the clutch lever 20 is being grasped so that power transmission from the engine 12 to the transmission 14 is disconnected, the neutral shift position, etc.). This determination is made based on the outputs of the clutch switch output detector 64g, neutral switch output detector 64h and the

like.

[0065] When the result in S34 is YES, the program proceeds to S36, in which it is determined whether the engine speed NE is equal to or greater than a predetermined engine speed #NEH. The predetermined engine speed #NEH is set to a value that can avoid a stall even when the accelerator 17 is rapidly opened by the operator during no load operation of the engine 12, e.g., 2000 rpm.

[0066] When the result in S36 is NO, the program proceeds to S38, in which the control difference of the motor 44 is calculated based on the actual throttle opening TPS and desired throttle opening information THd'V (control difference calculator 66a6), and to S40, in which the operation of the motor 44 is controlled based on the calculated control difference, i.e., so that the actual throttle opening TPS becomes the desired throttle opening THd'.

[0067] When the result in S34 is NO or when the result in S36 is YES, the program proceeds to S42, in which the control difference of the motor 44 is calculated based on the actual throttle opening TPS and desired throttle opening information THdV (i.e., a desired voltage of the throttle opening sensor 52 corresponding to the desired throttle opening THd calculated from the accelerator opening APS) calculated in unshown another processing, whereafter the processing of S40 is conducted.

[0068] FIG. 7 is a time chart for explaining the processing of S10 to S42 in the foregoing flowchart.

[0069] When the engine 12 is operated under no load at a time point to in FIG. 7, the operation of the motor 44 is controlled so that the actual throttle opening TPS becomes the desired throttle opening THd'. When the accelerator 17 is rapidly opened (snapped) by the operator at a time point t_1 , i.e., when the accelerator opening APS sharply increases, generally a calculation result of the desired throttle opening is to be a value following the accelerator opening APS. As a result, the actual throttle opening TPS becomes large as indicated by an imaginary line in FIG 7 and an amount of intake air sharply increases, resulting in high possibility of stall occurrence.

[0070] In the control system for the internal combustion engine according to this embodiment, since the desired throttle opening THd' is set to a value of upper limit that can prevent or avoid a stall based on the accelerator opening APS and engine speed NE, even when the accelerator opening APS sharply increases, the throttle valve 24 is opened only up to the upper limit value that can avoid a stall during time period from t_1 to t_2 . Thus it becomes possible to prevent a stall, while diminishing a difference between velocity of the accelerator manipulation and that of the throttle valve movement (i.e., not giving the operator uncomfortable feel).

[0071] After that, when the engine speed NE becomes equal to or greater than the predetermined engine speed #NEH (a value which can avoid a stall even when the accelerator 17 is rapidly opened by the operator) at a time point t_2 , the result in S36 should be YES and it is switched to normal operation.

[0072] The explanation of FIG. 4 is resumed. When

the result in S16 is NO, i.e., when the engine 12 is being started or a stall occurs, the program proceeds to S44, in which the control difference of the motor 44 is calculated based on the actual throttle opening TPS and desired throttle opening at starting/stalling information calculated in unshown another processing and then the processing of S40 is conducted, whereafter the program is terminated.

[0073] As stated in the foregoing, this embodiment is configured to have a system for (and method of) controlling an internal combustion engine (12) mounted on a vehicle (10) and having an actuator (44) that drives a throttle valve (24) installed in an intake pipe (23) of the engine and an accelerator (17) installed to be operable by the operator, characterized by: a throttle opening detector that detects actual opening TPS of the throttle valve (throttle opening sensor 52, throttle valve controller 66); an accelerator opening detector that detects opening APS of the accelerator (accelerator opening sensor 54, throttle valve controller 66, S10); an engine speed detector that detects speed of the engine (engine speed NE) (crank angle sensor 62, engine controller 64, S12); a desired throttle opening calculator that calculates desired opening THd of the throttle valve based on the detected opening APS of the accelerator and the detected engine speed NE (throttle valve controller 66, S20); a no-load condition determiner that determines whether the engine is operated under no load (throttle valve controller 66, S34); and an actuator controller that controls the operation of the actuator such that the detected actual opening TPS of the throttle valve becomes the calculated desired opening THd (desired throttle opening THd') when the engine is determined to be under no load (throttle valve controller 66, S38, S40).

[0074] With this, it becomes possible to set the desired throttle opening THd to an upper limit value that can prevent or avoid a stall based on the accelerator opening APS and engine speed NE. Further, the operation of the motor 44 for driving the throttle valve 24 is controlled such that the detected actual throttle opening TPS becomes the calculated desired throttle opening THd when the engine is operated under no load such as idling. Owing to this configuration, even when the accelerator 17 is rapidly opened by the operator during no load operation of the engine 12, the throttle valve 24 can be driven up to the upper limit with which a stall does not occur, so the difference between velocity of the accelerator manipulation and that of the throttle valve movement can be relatively small, thereby preventing the operator from having uncomfortable feel. In other words, it becomes possible to prevent a stall of the engine without impairing operating feel. Furthermore, since a stall is prevented, the engine speed at idling (idle speed) can be more lowered, thereby improving fuel efficiency.

[0075] The system further includes an engine temperature detector that detects temperature of the engine (coolant temperature TW) (coolant temperature sensor 60, throttle valve controller 66, S14); and a desired throt-

tle opening corrector that corrects the calculated desired opening of the throttle valve based on the detected engine temperature (throttle valve controller 66, S26, S30), and the actuator controller controls the operation of the actuator such that the detected actual opening of the throttle valve becomes the corrected desired opening THd (desired throttle opening THd') (throttle valve controller 66, S38, S40).

[0076] With this, it becomes possible to set the desired throttle opening THd to an upper limit value THd' that can reliably prevent a stall from occurring. Specifically, since the lubricant oil of the engine 12 changes in viscosity depending on the temperature of the engine 12 (coolant temperature TW), i.e., the viscosity lowers with increasing engine temperature, with this change, the upper limit of the desired throttle opening that can prevent a stall also changes. Therefore, correction of the desired throttle opening THd based on the temperature of the engine 12 makes possible to set the desired throttle opening THd to a value that can reliably prevent a stall.

[0077] It should be noted that the motorcycle 10 is used as an example of a saddle-seat vehicle on which the engine 12 is mounted, but it is not limited thereto and can be another type of saddle-seat vehicle such as a scooter, ATV (All Terrain Vehicle) or the like, a seat or saddle of which the operator straddles, or any other type of vehicle.

[0078] It should also be noted that the engine 12 can be a multi-cylinder engine in place of a single-cylinder engine.

[0079] It should also be noted that, although the coolant temperature TW is used as temperature of the engine 12, in the case of air-cooled engine, lubricant oil temperature can be detected and utilized.

[0080] It should further be noted that, although the displacement and full-firing engine speed of the engine 12 and the like are indicated with specific values, they are only examples and not limited thereto.

[0081] It should still further be noted that, although idling is exemplified as no load operation of the engine 12, it can be another condition such as a condition where the clutch lever 20 is being grasped so that power transmission from the engine 12 to the transmission 14 is disconnected, the neutral shift position, a case where engagement of the gear of the transmission 14 is released due to vibration at driving etc. and it becomes neutral (so-called "gear pop out").

Claims

1. A system for controlling an internal combustion engine (12) mounted on a vehicle (10) and having an actuator (44) that drives a throttle valve (24) installed in an intake pipe (23) of the engine and an accelerator (17) installed to be operable by the operator, characterized by:

a throttle opening detector that detects actual

opening of the throttle valve (52, 66);
 an accelerator opening detector that detects
 opening of the accelerator (54, 66, S10);
 an engine speed detector that detects speed of
 the engine (62, 64, S12); 5
 a desired throttle opening calculator that calcu-
 lates desired opening of the throttle valve based
 on the detected opening of the accelerator and
 the detected engine speed (66, S20);
 a no-load condition determiner that determines 10
 whether the engine is operated under no load
 (66, S34); and
 an actuator controller that controls the operation
 of the actuator (44) such that the detected actual
 opening of the throttle valve becomes the cal- 15
 culated desired opening when the engine is de-
 termined to be under no load (66, S38, S40).

2. The system according to claim 1, further including:

an engine temperature detector that detects
 temperature of the engine (60, 66, S14); and
 a desired throttle opening corrector that corrects
 the calculated desired opening of the throttle
 valve based on the detected engine temperature 25
 (66, S26, S30),
 and the actuator controller controls the opera-
 tion of the actuator such that the detected actual
 opening of the throttle valve becomes the cor-
 rected desired opening (66, S38, S40). 30

3. A method of controlling an internal combustion en-
 gine (12) mounted on a vehicle (10) and having an
 actuator (44) that drives a throttle valve (24) installed
 in an intake pipe (23) of the engine and an accelera- 35
 tor (17) installed to be operable by the operator,
characterized by:

detecting actual opening of the throttle valve (52,
 66); 40
 detecting opening of the accelerator (54, 66,
 S10);
 detecting speed of the engine (62, 64, S12);
 calculating desired opening of the throttle valve
 based on the detected opening of the accelera- 45
 tor and the detected engine speed (66, S20);
 determining whether the engine is operated un-
 der no load (66, S34); and
 controlling the operation of the actuator (44)
 such that the detected actual opening of the 50
 throttle valve becomes the calculated desired
 opening when the engine is determined to be
 under no load (66, S38, S40).

4. The method according to claim 3, further including 55
 the steps of:

detecting temperature of the engine (60, 66,

S14); and
 correcting the calculated desired opening of the
 throttle valve based on the detected engine tem-
 perature (66, S26, S30),
 and the step of controlling controls the operation
 of the actuator such that the detected actual
 opening of the throttle valve becomes the cor-
 rected desired opening (66, S38, S40).

FIG. 1

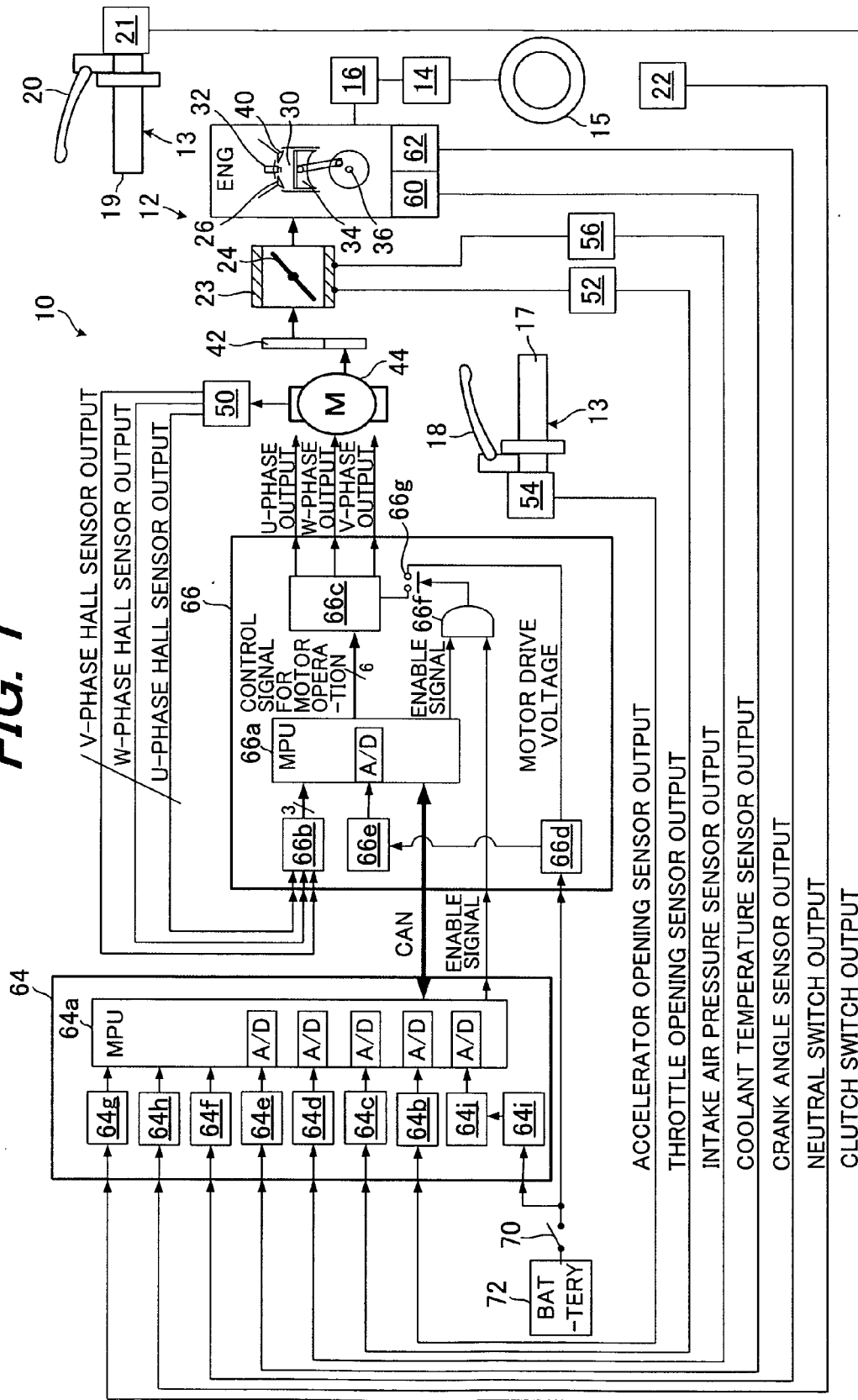


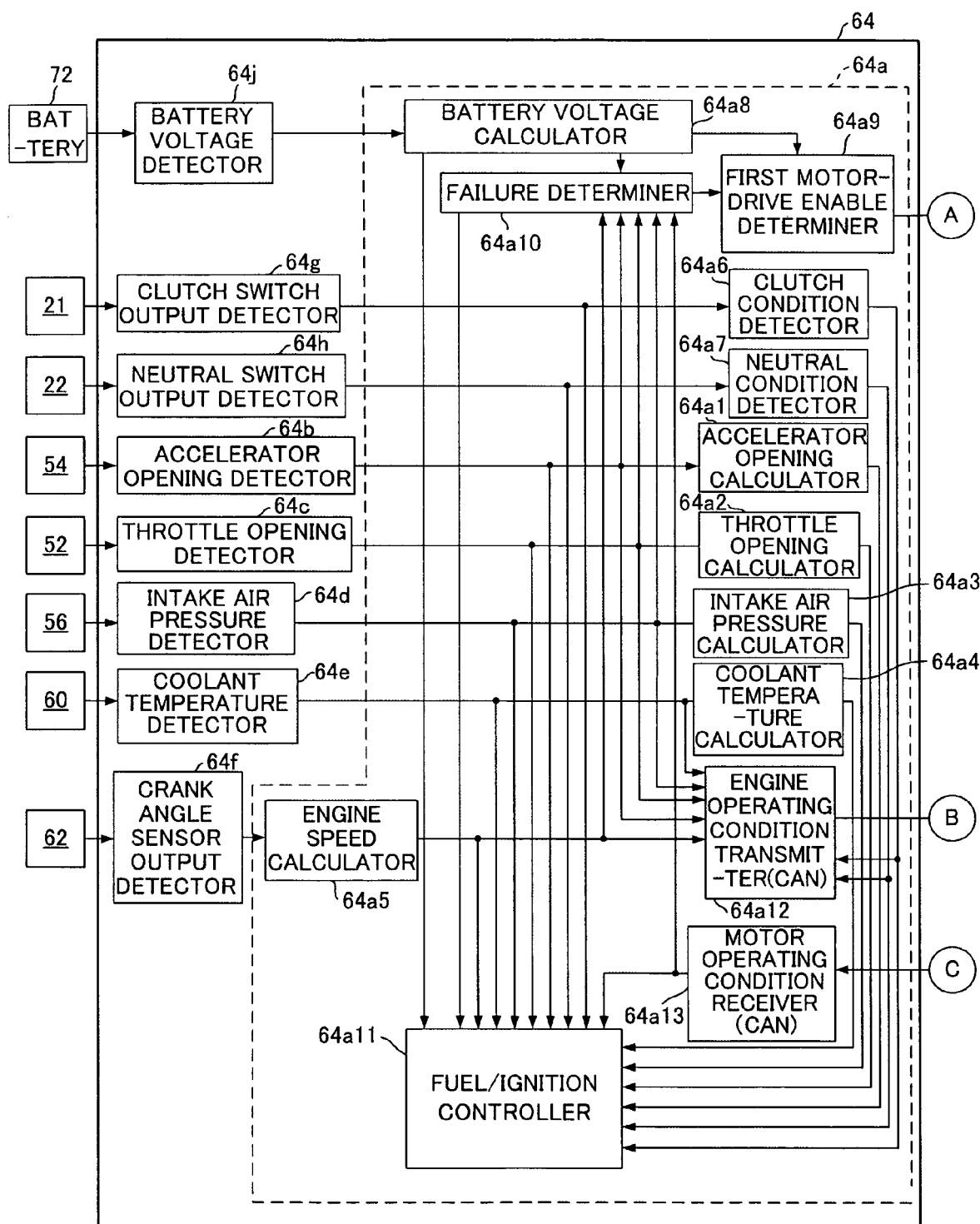
FIG. 2

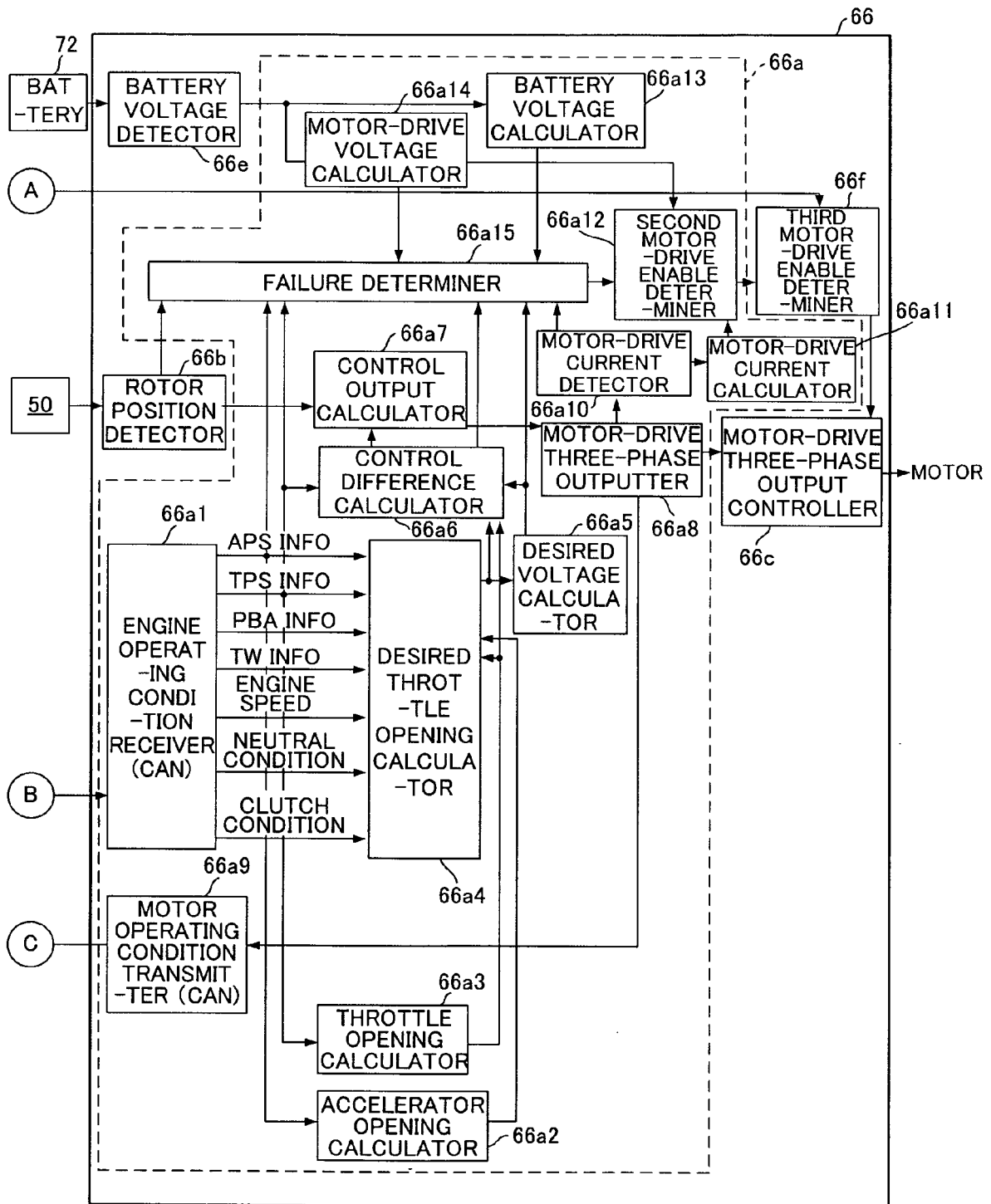
FIG. 3

FIG. 4

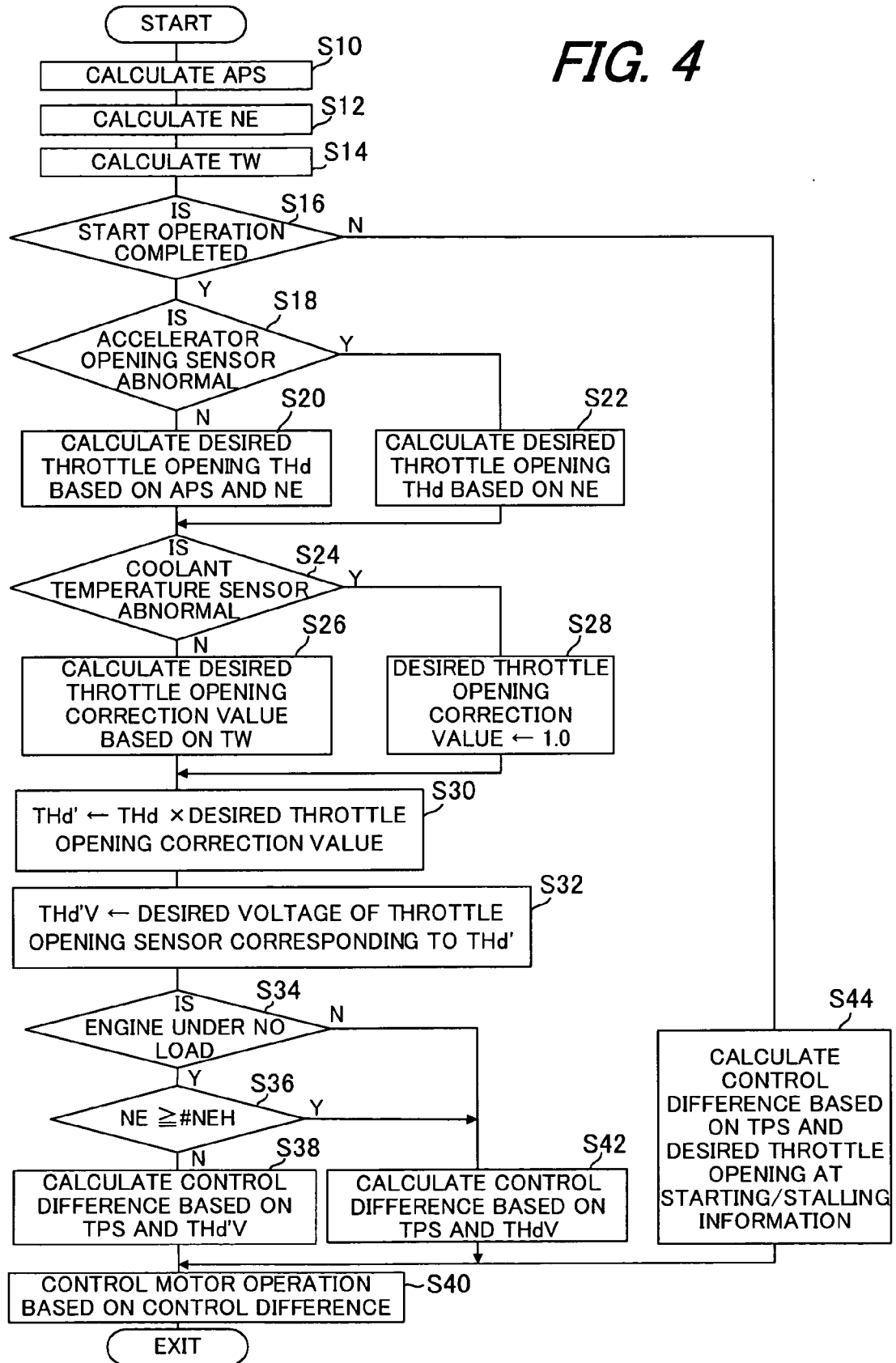


FIG. 5

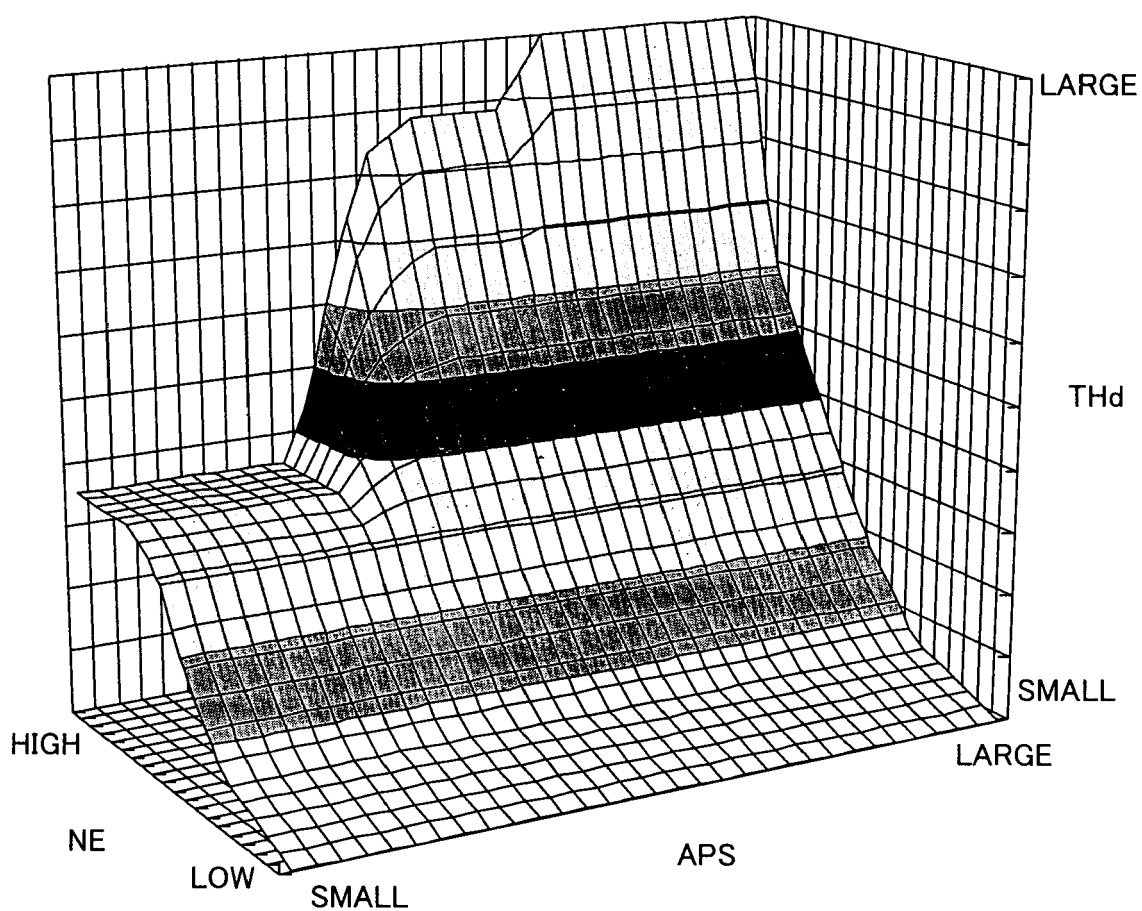


FIG. 6

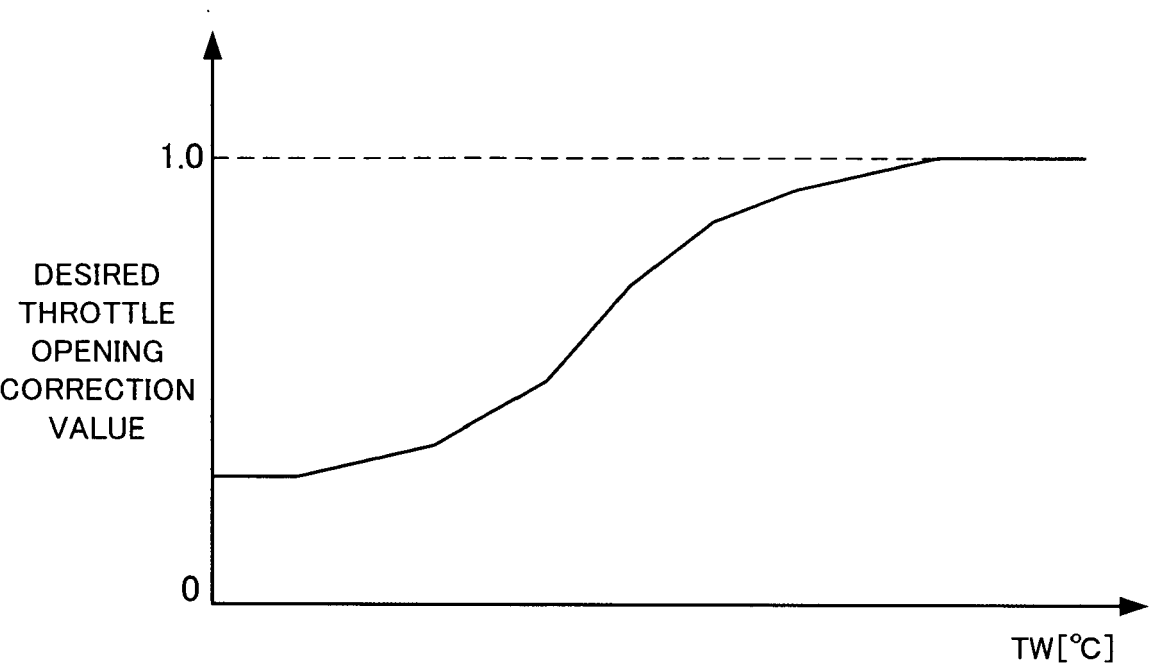
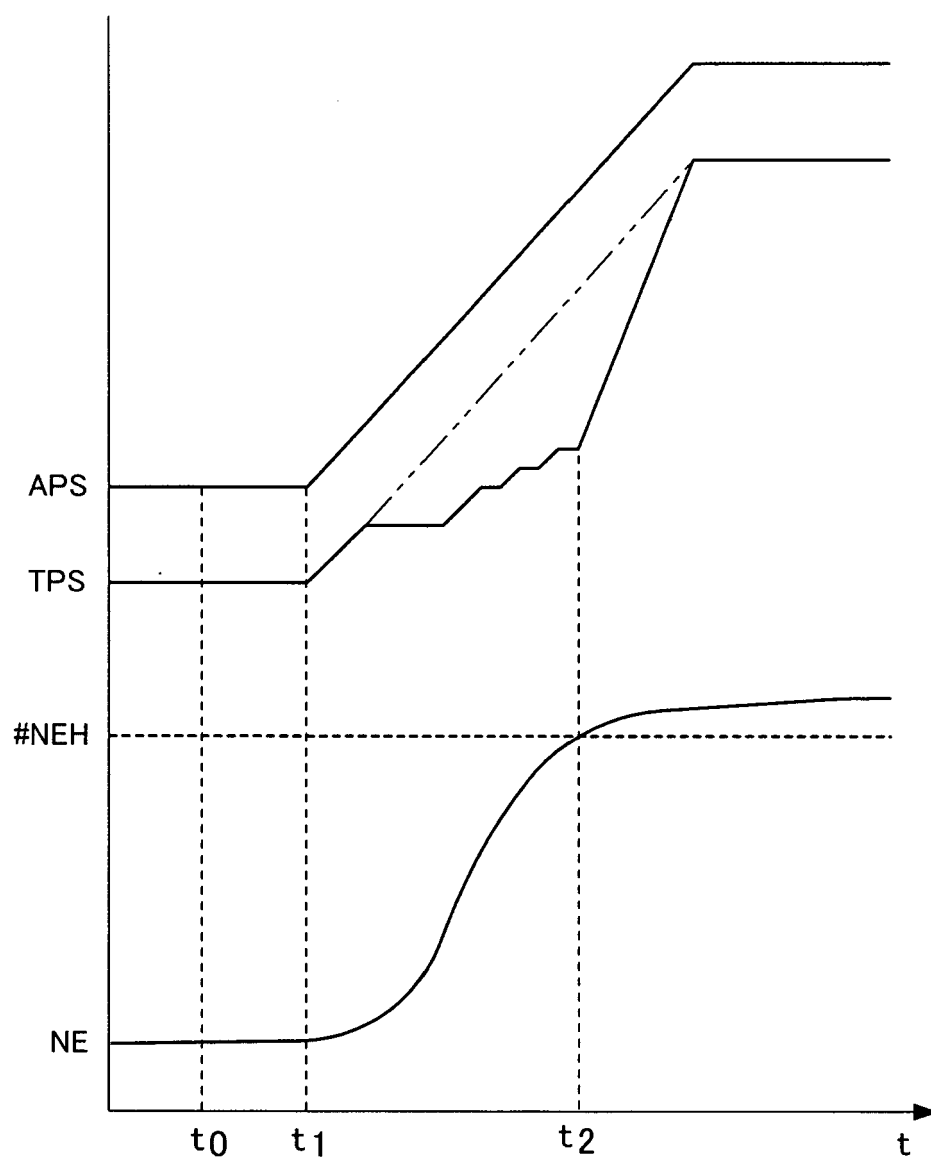


FIG. 7



REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

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