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(54) **ENGINE UNIT**

MOTOREINHEIT

UNITÉ DE MOTEUR

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Description

TECHNICAL FIELD

[0001] The present teaching relates to an engine unit that includes a high-load region and a low-load region in four strokes and starts by cranking a crankshaft with a starter motor.

BACKGROUND ART

[0002] A known engine of a vehicle is a four-stroke engine (e.g., a single-cylinder engine) that includes, in four strokes, a high-load region where a load for rotating a crankshaft of the engine is high and a low-load region where the load for rotating the crankshaft of the engine is small.

[0003] Patent Document 1 (Japanese Patent Application Publication No. 2003-343404) discloses an engine starting apparatus that starts an engine by temporarily rotating a crankshaft in a reverse direction to stop the crankshaft and then rotating the crankshaft in a normal direction.

[0004] In the engine starting apparatus of Patent Document 1, after the rotation of the crankshaft of the engine has stopped, a motor causes the crankshaft to rotate in the reverse direction to a position at which the load increases in the reverse rotation, that is, halfway in an expansion stroke. Thereafter, the engine starting apparatus rotates the motor in the normal direction from the halfway position in the expansion stroke to thereby rotate the crankshaft in the normal direction.

[0005] As described above, the crankshaft is rotated in the reverse direction to the position at which the load increases, that is, the halfway position in the expansion stroke so that the crankshaft rotates in a low-load region from halfway of the expansion stroke to a compression stroke in starting the engine. Subsequently, the engine reaches a first high-load region. Thus, before the engine reaches the first high-load region, the rotation speed of the crankshaft can be increased. By using both of a large inertial force with the high rotation speed and an output torque of a starter motor, the engine can pass over the first high-load region.

[0006] Patent Document 2 (International Patent Publication No. WO2015/093576) discloses an engine unit in which while the crankshaft rotates in the normal direction after a combustion operation of a four-stroke engine body has stopped, a resistance is applied to the normal rotation of the crankshaft with a three-phase brushless motor.

[0007] The engine unit stops the crankshaft at a position of a compression stroke in the four-stroke engine body. Then, in accordance with an input of a start instruction in stopping the crankshaft, the three-phase brushless motor rotates the crankshaft in the normal direction from the stop position of the compression stroke.

[0008] Accordingly, in the case of starting the four-stroke engine body in accordance with the input of the start instruction, even with a small output torque of the motor, the rotation of the crankshaft can be started at a position at which the four-stroke engine can be easily started.

[0009] In the case where the crankshaft starts rotating in accordance with the input of the start instruction as described above, the rotation speed of the crankshaft gradually increases from the stopped state. In the case where the normal rotation of the crankshaft starts from the compression stroke, the rotation speed of the crankshaft is low in the compression stroke. As described above, in the case where the rotation speed of the crankshaft is low in the compression stroke, the crankshaft is not affected by a compression reaction force by a gas in a combustion chamber. Consequently, the crankshaft can rotate quickly over a load in the high-load region of the compression stroke.

CITATION LIST

PATENT DOCUMENT

[0010]

Patent Document 1: Japanese Patent Application Publication No. 2003-343404

Patent Document 2: International Patent Publication No. WO2015/093576 US 2007/0079782 A1 describes a device for controlling an internal combustion engine upon starting, wherein fuel injection is performed in a low-load region in four strokes, wherein air-fuel mixture is ignited, and wherein a starting strategy is determined based on operating parameters such as a piston position and engine temperature. On the basis of this strategy control parameters for a run-up to engine operating speed are defined.

SUMMARY OF INVENTION

TECHNICAL PROBLEM

[0011] The inventors of the present teaching evaluated startability of the engine in which the high-load region and the low-load region are present in four strokes as described in Patent Documents 1 and 2. Consequently, the inventors of the present teaching found that in some specific phases, a load varies largely so that startability of the engine degrades.

[0012] It is therefore an object of the present teaching to provide a configuration capable of enhancing startability in the engine in which the high-load region and the low-load region are present in four strokes.

SOLUTION TO PROBLEM

[0013] The inventors of the present teaching evaluated startability of a previously presented engine in which a high-load region and a low-load region are present in four strokes.

[0014] The previously presented engine in which the high-load region and the low-load region are present in four strokes, startability of the engine is enhanced by utilizing an inertial force obtained by increasing the rotation speed of the crankshaft in the low-load region. Thus, the engine basically shows excellent startability.

[0015] However, through the examination, the inventors of the present teaching found that in some specific phases, a large variation of a load of the engine degrades startability of the engine conversely when the rotation speed of the crankshaft is increased in the low-load region.

[0016] Specifically, in the engine in which the high-load region and the low-load region are present in four strokes, even with an extremely low engine temperature, the rotation speed of the crankshaft increases in the low-load region. In particular, with an extremely low engine temperature, the load of the engine further increases, and thus, control of increasing an inertial force by increasing the rotation speed of the crankshaft in the low-load region is considered to be preferable.

[0017] However, if the rotation speed of the crankshaft is increased in the low-load region with an extremely low engine temperature, vaporization of injected fuel is suppressed under a reduced vapor pressure of fuel due to the temperature decrease. This suppression of vaporization and the increase in the rotation speed of the crankshaft reduce the time from fuel injection start to completion of an intake stroke. Accordingly, the amount of fuel flowing into a combustion chamber decreases.

[0018] Consequently, the total heat generation amount of fuel contributing to combustion decreases so that a toque obtained by combustion cannot be sufficiently obtained, and the engine cannot be started in some cases. In addition, in the engine in which the high-load region and the low-load region are present in four strokes, a large combustion interval might cause a similar phenomenon in next combustion.

[0019] As described above, in the engine in which the high-load region and the low-load region are present in four strokes, when the rotation speed of the crankshaft is increased in the low-load region with an extremely low engine temperature, startability might degrade conversely, in some cases. The inventors of the present teaching found the foregoing phenomenon through the evaluation of startability of the engine in which the high-load region and the low-load region are present in four strokes.

[0020] As disclosed in Patent Documents 1 and 2, in the engine in which the high-load region and the low-load region are present in four strokes, startability is enhanced by using an inertial force obtained by increasing the rotation speed of the crankshaft in the low-load region. Since the load of the engine further increases with an extremely low engine temperature, it is not conceivable to reduce the inertial force by suppressing an increase in the rotation speed of the crankshaft in the low-load region.

[0021] However, in the case of a permanent magnet starter motor, a torque can be increased as the rotation speed decreases. The inventors of the present teaching found that in the engine in which the high-load region and the low-load region are present in four strokes, such a characteristic of a permanent magnet starter motor can be used for sufficiently increasing the energy obtained by the first combustion even when an increase in the rotation speed of the crankshaft is suppressed in the low-load region after the rotation of the crankshaft from the stopped state and before the first combustion with an extremely low engine temperature. In addition, in an engine temperature region where startability does not degrade, the increase in the rotation speed of the crankshaft can be promoted in the low-load region after the rotation of the crankshaft from the stopped state and before the first combustion, and startability as the same level as before can be obtained.

[0022] Based on the results of the examination described above, it is the object of the present invention to provide an engine unit and a method for controlling an engine unit as indicated above that improves startability of the engine. According to the present invention said object is solved by an engine unit according to the independent claim 1. Moreover, said object is solved by a method for controlling an engine unit according to the independent claim 9.

[0023] Preferred embodiments are laid down in the dependent claims.

[0024] The present teaching employs the following configuration in order to solve the problem described above.

(1) An engine unit according to one embodiment of the present teaching includes:

a four-stroke engine body including a combustion chamber having an intake port and an exhaust port, an intake valve configured to open and close the intake port, an exhaust valve configured to open and close the exhaust port, an intake passage connected to the intake port and configured to guide air in the atmosphere into the combustion chamber through the intake port, an exhaust passage connected to the exhaust port, a fuel injection device configured to inject fuel into the intake passage, an ignition device configured to ignite an air-fuel mixture including fuel and air in the combustion chamber, a piston configured to move to and fro in the combustion chamber, and a crank shaft connected to the piston to rotate in accordance with the to-and-fro movement of the piston, a high-load region where a load for rotating the crank shaft is high and a low-load region where the load for rotating the crank shaft is low being present in four strokes: a permanent magnet starter motor that includes a permanent magnet and is configured to rotate the crank shaft; a control device that controls the permanent magnet starter motor, the fuel injection device, and the ignition device; an engine temperature detector that detects a temperature of the four-stroke engine body; and a crank angle detector that detects a crank angle, the crank angle being a position of a rotation angle of the crank shaft, wherein the control device drives the permanent magnet starter motor to rotate the crank shaft from a stopped state, controls the fuel injection device while a crank angle of the crank shaft is in the low-load region, thereby injecting fuel into the intake passage, controls a rotation speed of the permanent magnet starter motor so that an increase in a rotation speed of the crank shaft is suppressed, based on the temperature of the four-stroke engine body detected by the engine temperature detector while the crank angle of the crank shaft is in the low-load region and from when the fuel injection device injects fuel into the intake passage to when the intake valve is closed, and starts the four-stroke engine body by igniting the air-fuel mixture in the combustion chamber by using the ignition device while the crank angle of the crank shaft is in the high-load region.

With the configuration described above, the rotation speed of the permanent magnet starter motor is controlled in accordance with the temperature of the engine unit so that the rotation speed of the crankshaft can be reduced. Thus, the fuel injection time is increased so that the time for fuel evaporation in accordance with the engine temperature can be obtained. In addition, since the permanent magnet starter motor has a large torque in low-speed rotation, energy sufficient for starting the engine can be obtained. Thus, this configuration described above can enhance startability of the engine.

(2) In another aspect, the engine unit according to the present teaching preferably includes a configuration as follows: The control device controls the rotation speed of the permanent magnet starter motor such that a rotation speed of the crank shaft obtained when the temperature of the four-stroke engine body detected by the engine temperature detector is a first temperature is lower than a rotation speed of the crank shaft obtained when the temperature of the four-stroke engine body detected by the engine temperature detector is a second temperature higher than the first temperature.

With this configuration, at a low engine temperature, the time for fuel evaporation can be obtained so that startability of the engine can be enhanced.

(3) In yet another aspect, the engine unit according to the present teaching preferably includes a configuration as follows: The fuel injection device injects fuel toward the intake valve. The injection of fuel to a position near the intake port can increase efficiency of fuel supply.

(4) In still another aspect, the engine unit according to the present teaching preferably includes a configuration as follows: The control device determines a rotation speed of the crank shaft in accordance with a fuel injection time determined based on the temperature of the four-stroke engine body detected by the engine temperature detector.

With this configuration, control of the fuel injection time in accordance with the engine temperature can be easily performed. Thus, start of the engine can be more efficiently controlled.

(5) In still another aspect, the engine unit according to the present teaching preferably includes a configuration as follows: The engine temperature detector is a sensor that detects a temperature of a coolant of the four-stroke engine body or a temperature of oil in an oil passage. With this configuration, the sensor necessary as a function of the engine is shared so that the configuration of the engine unit can be simplified.

(6) In still another aspect, the engine unit according to the present teaching preferably includes a configuration as follows: The control device causes the fuel injection device to inject fuel until the fuel injection time exceeds a predetermined time in which fuel necessary for engine start is allowed to be supplied. With this configuration, a predetermined amount or more of fuel supply to the engine can be obtained so that startability of the engine can be enhanced.

(7) In still another aspect, the engine unit according to the present teaching preferably includes a configuration as follows: The control device controls the rotation speed of the motor such that as the temperature of the four-stroke engine body detected by the engine temperature detector decreases, the rotation speed of the crank shaft in the fuel injection time decreases. With this configuration, the time for fuel evaporation at low temperatures can be obtained so that startability of the engine can also be enhanced at low temperatures.

(8) In still another aspect, the engine unit according to the present teaching preferably includes a configuration as follows: The four-stroke engine body further includes a decompression mechanism that temporarily opens the exhaust valve in order to eject the air-fuel mixture in the combustion chamber while the crank angle of the crank shaft is in the high-load region. In the configuration, including the decompression mechanism as described above, the rotation speed of the crankshaft might be insufficiently increased by the first combustion in starting the engine. On the other hand, application of the configurations described above enables energy for starting the engine to be obtained by the first combustion, and thus, startability of the engine can be enhanced.

[0025] The terminology used herein is used for the purpose of defining some particular embodiments only and is not intended to limit the present teaching. As used herein, the term "and/or" includes any and all combinations of one or more of the associated listed items.

[0026] It will be further understood that the terms "including," "comprising" or "having" and the variations thereof when used in this specification, specify the presence of stated features, steps, elements, components, and/or their equivalents, but can include steps, operations, elements, components, and/or one or more of the groups.

[0027] It will be further understood that the terms "mounted," "connected," "coupled," and/or their equivalents are used broadly and encompass both direct and indirect mounting, connecting and coupling. Further, "connected" and "coupled" are not restricted to physical or mechanical connections or couplings, and can include direct or indirect connections or couplings.

[0028] Unless otherwise defined, all the terms (including technical and scientific terms) used herein have the same meaning as commonly understood by one having ordinary skill in the art to which this present teaching belongs.

[0029] It will be further understood that terms, such as those defined in commonly used dictionaries, should be interpreted as having a meaning that is consistent with their meaning in the context of the relevant art and the present disclosure and will not be interpreted in an idealized or overly formal sense unless expressly so defined herein.

[0030] In describing the present teaching, it will be understood that a number of techniques and steps are disclosed. Each of these has individual benefit and each can also be used in conjunction with one or more, or in some cases all, of the other disclosed techniques.

[0031] In the following description, numerous specific examples are set forth in order to provide a thorough understanding of the present teaching. It will be evident, however, to one skilled in the art that the present teaching may be practiced without these specific examples.

[0032] Therefore, the following disclosure is to be considered as an exemplification of the present teaching, and is not intended to limit the present teaching to the specific embodiments illustrated by the figures or description below.

<Definition of Cranking>

[0033] Cranking herein refers to rotation of a crankshaft by applying an external force from outside an engine without using combustion in cylinders of an engine. In particular, cranking refers to the rotation of the crankshaft by using a motor for starting the engine in starting the engine. The term "cranking" includes application of an external force to the crankshaft while combustion occurs in cylinders of the engine.

<Definition of High-load Region>

[0034] The high-load region of the engine herein refers to a region where a torque necessary for compressing an in-cylinder gas is high in a compression stroke in an operation range of the engine. The high-load region of the engine includes the compression stroke.

<Definition of Low-load Region>

[0035] The low-load region of the engine herein refers to a region where the in-cylinder gas is not compressed in the operation range of the engine.

<Definition of Temperature of Four-stroke Engine>

[0036] The temperature of the four-stroke engine body herein refers to a temperature in a combustion chamber of the engine or a temperature detected by an engine temperature detector for detecting a temperature concerning a temperature in the combustion chamber. The temperature concerning the temperature in the combustion chamber refers to a temperature that varies depending on the temperature in the combustion chamber, such as a temperature of a coolant, temperatures of a cylinder and a crankcase body of the four-stroke engine body, a fuel temperature, an injector temperature, and an intake port temperature. This temperature may be a temperature of oil in an oil passage in the case of an air cooling engine, for example.

ADVANTAGEOUS EFFECTS OF INVENTION

[0037] An engine unit according to one embodiment of the present teaching can enhance startability of an engine.

BRIEF DESCRIPTION OF DRAWINGS

[0038]

[FIG. 1] FIG. 1 is a schematic view illustrating a configuration of an engine unit according to the first embodiment.

[FIG. 2] FIG. 2 is an illustration showing a relationship between a crank angle and a torque necessary for cranking in starting an engine.

[FIG. 3] FIG. 3 is a flowchart depicting an operation of rotation speed control of a permanent magnet starter motor by an ECU in starting the engine unit illustrated in FIG. 1.

[FIG. 4] FIG. 4 is a graph showing a relationship between an engine speed and a crank angle in starting the engine unit illustrated in FIG. 1.

[FIG. 5] FIG. 5 is a view illustrating an example of a motion of a crankshaft in starting the engine unit illustrated in FIG. 1.

[FIG. 6] FIG. 6 is a graph schematically showing a relationship between an opening degree of an exhaust valve and a crank angle in the engine unit illustrated in FIG. 1.

[FIG. 7] FIG. 7 is a graph showing engine speeds at a high engine temperature and a low engine temperature in starting the engine unit illustrated in FIG. 1.

[FIG. 8A] FIG. 8A is a graph showing an example of a relationship between an engine temperature and a rotation speed of the crankshaft in starting the engine.

[FIG. 8B] FIG. 8B is a graph showing another example of the relationship between the engine temperature and the rotation speed of the crankshaft in starting the engine.

[FIG. 9] FIG. 9 illustrates a schematic configuration of the engine unit, while showing an example of a relationship between an engine temperature and a rotation speed of the crankshaft in starting the engine and a relationship between a crank angle and a necessary torque in starting the engine.

[FIG. 10] FIG. 10 is a schematic view illustrating a configuration of an engine unit according to the second embodiment.

[FIG. 11] FIG. 11 is a graph showing an example of a comparison with the cases of a different fuel injection position in the relationship between the engine temperature and the rotation speed of the crankshaft in starting the engine.

DESCRIPTION OF EMBODIMENTS

First Embodiment

[0039] The embodiments will be described hereinafter with reference to the drawings. In the drawings, the same parts are denoted by the same reference numerals, and the description thereof will not be repeated. The dimensions of the components in the drawings do not strictly represent actual dimensions of the components and dimensional proportions of the components.

<Configuration of Engine Unit>

[0040] A configuration of an engine unit 100 will be described. The engine unit 100 is provided in a motorcycle, which is an example of a vehicle. FIG. 1 is a view schematically illustrating a configuration of the engine unit 100. The following description will be directed to a case where the engine unit 100 includes a single-cylinder four-stroke engine body 10 (hereinafter referred to simply as an engine 10). In FIG. 1, the components of the engine unit 100 are simplified. The engine unit 100 according to this embodiment is an engine unit including a four-stroke engine 10 in which an intake stroke, a compression stroke, an expansion stroke, and an exhaust stroke are included in one cycle.

[0041] As illustrated in FIG. 1, the engine unit 100 includes the engine 10, an air cleaner 12, an intake pipe 14a, an intake pipe 14b, an exhaust pipe 16, a throttle device 20, a throttle position sensor (hereinafter referred to as a TPS) 22, a pressure sensor 24, a crank angle sensor 26 (crank angle detector), an engine temperature sensor 28 (engine temperature detector), a permanent magnet starter motor 30, an engine control device (control unit, hereinafter referred to as an ECU) 32, an inverter 62, a battery 64, and a start switch 66. First, the components except for the engine 10 will be briefly described.

[0042] The air cleaner 12 takes air in the atmosphere (air outside the vehicle including the engine 10) and purifies the intake air. An end of the intake pipe 14a is connected to the air cleaner 12. The other end of the intake pipe 14a is connected to a throttle body 20c described later of the throttle device 20. An end of the intake pipe 14b is connected to the throttle body 20c of the throttle device 20. The other end of the intake pipe 14b is connected to a passage 34a formed in a cylinder head 34 described later. An end of the exhaust pipe 16 is connected to the passage 34b formed in the cylinder head 34 described later. In this embodiment, an intake passage 33a is formed by, for example, a space inside the intake pipe 14a, a space inside the throttle body 20c, a space inside the intake pipe 14b, and the passage 34a. In this embodiment, an exhaust passage 33b is formed by, for example, the passage 34b and a space inside the exhaust pipe 16.

[0043] The intake passage 33a guides air in the atmosphere purified by the air cleaner 12 into a combustion chamber 36 described later of the engine 10 through an intake port 35a described later. On the other hand, the exhaust passage 33b exhausts air in the combustion chamber 36 to the atmosphere (outside the vehicle) through an exhaust port 35b described later.

[0044] The configuration of the intake passage 33a is not limited to the configuration illustrated in FIG. 1, and only needs to guide air in the atmosphere to the combustion chamber 36 described later. The configuration of the exhaust passage 33b is not limited to the configuration illustrated in FIG. 1, and only needs to discharge a gas in the combustion chamber 36 to the atmosphere. In the following description, the terms of "upstream" and "downstream" refer to "upstream" and "downstream" with respect to an airflow direction from the air cleaner 12 to the exhaust passage 33b through the intake passage 33a and the engine 10.

[0045] The throttle device 20 includes a throttle valve 20a, a driving device 20b for driving the throttle valve 20a, and a throttle body 20c. The throttle valve 20a and the driving device 20b are disposed in the throttle body 20c. As the driving device 20b, an electric motor may be used, for example.

[0046] The throttle valve 20a is driven by the driving device 20b to thereby adjust an opening area of the intake passage 33a. That is, in this embodiment, the throttle valve 20a serves as a regulating valve that adjusts the opening area of the intake passage 33a. As will be described later, the driving device 20b is controlled by an ECU 32.

[0047] The TPS 22 detects a position of the throttle valve 20a as a throttle opening angle. The TPS 22 outputs a signal indicating the detected throttle opening angle to the ECU 32.

[0048] The pressure sensor 24 detects a pressure (intake pressure) of a space downstream of the throttle valve 20a in the intake passage 33a. That is, the pressure sensor 24 detects a pressure of a space between the throttle valve 20a and the combustion chamber 36 described later in the intake passage 33a. In the following description, the intake pressure refers to a pressure of a space between the throttle valve 20a and the combustion chamber 36 in the intake passage 33a. The pressure sensor 24 outputs a signal concerning the detected pressure to the ECU 32. In this embodiment, the pressure sensor 24 is a pressure detector.

[0049] The crank angle sensor 26 detects a rotation position (hereinafter referred to as a crank angle) of a crankshaft 46 described later of the engine 10. The crank angle sensor 26 outputs a signal indicating the detected crank angle (crank pulse signal) to the ECU 32.

[0050] Based on the signal output from the crank angle sensor 26, the ECU 32 ignites an air mixture in the combustion chamber 36 by an ignition plug 56 described later of the engine 10.

[0051] The configuration and operation of the ECU 32 described above are similar to those of a conventional ECU, and will not be described in detail.

[0052] The ECU 32 performs operation control in starting the engine. Specifically, the ECU 32 includes a rotation speed calculator 70, a crank angle determiner 71, a fuel injection time determiner 72, a motor controller 73, a fuel injection controller 74, an ignition controller 75, and a memory 76.

[0053] The rotation speed calculator 70 calculates a rotation speed of the engine 10, that is, a rotation speed of the crankshaft 46, based on the crank pulse signal output from the crank angle sensor 26. The rotation speed of the crankshaft 46 calculated by the rotation speed calculator 70 is input to the motor controller 73 and is used for feedback control of the permanent magnet starter motor 30.

[0054] The crank angle determiner 71 determines whether the crank angle obtained based on the crank pulse signal output from the crank angle sensor 26 is larger than a predetermined angle or not, and determines whether the crank angle is larger than a specified angle at which fuel injection starts or not. The determination result by the crank angle determiner 71 is input to the motor controller 73 and used for driving control of the permanent magnet starter motor 30. The determination result by the crank angle determiner 71 is input to the fuel injection controller 74, and used for driving control of a fuel injection device 54 described later of the engine 10. The predetermined angle is an angle smaller than the specified angle.

[0055] Based on engine temperature information output from the engine temperature sensor 28, the fuel injection time determiner 72 obtains a fuel injection time in accordance with an engine temperature from injection time data previously stored in the memory 76. In injecting fuel from the fuel injection device 54, the fuel injection time determiner 72 calculates a cumulative time of fuel injection (cumulative fuel injection time), and determines whether the calculated cumulative fuel injection time is longer than a default value (predetermined time) or not.

[0056] The engine temperature sensor 28 is, for example, a sensor for measuring a temperature of a coolant of the engine 10. The engine temperature sensor 28 may directly measure a temperature in the combustion chamber 36 or may measure a temperature in a cylinder 40 or a crankcase 44, for example, of the engine 10. That is, the engine temperature sensor 28 may be disposed at any position as long as the engine temperature sensor 28 can measure a temperature concerning the combustion chamber 36 of the engine 10.

[0057] The motor controller 73 controls driving of the permanent magnet starter motor 30 in starting the engine, based on the rotation speed of the crankshaft 46 output from the rotation speed calculator 70 and the determination result output from the crank angle determiner 71. Specifically, the motor controller 73 performs rotation speed control of the permanent magnet starter motor 30 in accordance with the determination result output from the crank angle determiner 71, and performs feedback control of the permanent magnet starter motor 30 by using the rotation speed of the crankshaft 46.

[0058] If the crank angle determiner 71 determines that the crank angle is larger than the specified angle at which fuel injection starts, the fuel injection controller 74 causes the fuel injection device 54 to inject fuel. On the other hand, if the fuel injection time determiner 72 determines that the cumulative fuel injection time is longer than the default value, the fuel injection controller 74 stops fuel injection by the fuel injection device 54.

[0059] The ignition controller 75 ignites the ignition plug 56 at the time when the crank angle obtained based on the crank pulse signal output from the crank angle sensor 26 reaches an ignition timing of the ignition plug 56.

[0060] The permanent magnet starter motor 30 is a motor that cranks the crankshaft 46 to start the engine 10. In this embodiment, the permanent magnet starter motor 30 is a DC brushless motor. The permanent magnet starter motor 30 has a characteristic that the torque increases as the rotation speed decreases.

[0061] As the DC brushless motor, a DC brushless motor of a type that detects an electrical angle by using a Hall sensor or a DC brushless motor of a type that detects a mechanical angle by using a crank pulse can be used.

[0062] An output shaft of the permanent magnet starter motor 30 is connected to the crankshaft 46 of the engine 10 to rotate the crankshaft 46. In this embodiment, the output shaft of the permanent magnet starter motor 30 is connected to the crankshaft 46 through no power transmission mechanism (e.g. a belt, a chain, a gear, a speed reducer, or a speed-up gear). It should be noted that the permanent magnet starter motor 30 only needs to be connected to the crankshaft 46 of the engine 10 such that the crankshaft 46 can rotate in the normal direction.

Thus, the permanent magnet starter motor 30 may be connected to the crankshaft 46 through the power transmission mechanism. The rotation axis of the permanent magnet starter motor 30 may substantially coincide with a rotation axis of the crankshaft 46.

[0063] The inverter 62 controls a current to be supplied from the battery 64 to the permanent magnet starter motor 30 to thereby control the rotation speed of the permanent magnet starter motor 30. The inverter 62 is controlled by the motor controller 73 of the ECU 32.

[0064] The battery 64 supplies electric power to the permanent magnet starter motor 30 through the inverter 62.

[0065] At startup of the engine 10, the start switch 66 outputs an ON signal in accordance with an operation of a driver or in the case where conditions for engine start are satisfied in an idling stop system described later. When the ON signal is output from the start switch 66, the ECU 32 starts rotation speed control of the permanent magnet starter motor 30 in order to start the engine 10.

[0066] The configuration of the engine 10 will now be described. As the configuration of the engine 10, various known engine configurations may be employed, and thus, the components of the engine will not be described in detail.

[0067] The engine 10 includes the cylinder head 34, the cylinder 40, a piston 42, the crankcase 44, the crankshaft 46, a connecting rod 48, an intake valve 50, an exhaust valve 52, the fuel injection device 54, and the ignition plug 56 (ignition device).

[0068] The piston 42 is movable to and fro in the cylinder 40. The crankshaft 46 is rotatable in the crankcase 44. The piston 42 and the crankshaft 46 are coupled to each other by the connecting rod 48. The to-and-fro movement of the piston 42 is transferred to the crankshaft 46 through the connecting rod 48. Accordingly, the crankshaft 46 rotates.

[0069] In the engine 10, the combustion chamber 36 is formed by the cylinder head 34, the cylinder 40, and the piston 42. The combustion chamber 36 includes the intake port 35a and the exhaust port 35b. The cylinder head 34 includes the passage 34a to be connected to the intake port 35a and the passage 34b to be connected to the exhaust port 35b. In this embodiment, the passage 34a connects the intake pipe 14b and the combustion chamber 36 to each other. The passage 34b connects the combustion chamber 36 and the exhaust pipe 16 to each other.

[0070] The intake valve 50 opens and closes the intake port 35a. The exhaust valve 52 opens and closes the exhaust port 35b. The intake valve 50 is driven by an unillustrated known valve mechanism. Similarly, the exhaust valve 52 is driven by an unillustrated valve mechanism.

[0071] In one cycle, the intake valve 50 is opened before the exhaust valve 52 is closed, and the intake valve 50 is closed before the exhaust valve 52 is opened. In other words, at least in the low-load operation range, the intake stroke is started before the exhaust stroke is finished.

[0072] Specifically, the intake valve 50 is open at a crank angle of, for example, 344 degrees to 576 degrees. The crank angle while the intake valve 50 is open is not limited to the range described above, and the intake valve 50 may be open with a crank angle of 360 degrees to 540 degrees at minimum and 326 degrees to 610 degrees at maximum.

[0073] The exhaust valve 52 is open at least in the exhaust stroke. Specifically, the exhaust valve 52 is open at a crank angle of, for example, 64 degrees to 378 degrees. The crank angle while the exhaust valve 52 is open is not limited to the range described above, and the exhaust valve 52 may be open with a crank angle of 180 degrees to 360 degrees at minimum and 70 degrees to 390 degrees at maximum.

[0074] The fuel injection device 54 injects fuel into the intake passage 33a. In this embodiment, the fuel injection device 54 injects fuel toward the intake valve 50. Fuel supplied into the intake passage 33a is sent to the combustion chamber 36 as an air-fuel mixture together with air. The ignition plug 56 ignites the air-fuel mixture in the combustion chamber 36.

[0075] The fuel injection device 54 and the ignition plug 56 perform fuel injection and ignition by control of the ECU 32 at appropriate timings in accordance with the strokes in one cycle of the engine 10.

[0076] A decompression mechanism 58 is provided near an unillustrated camshaft for driving the exhaust valve 52. The decompression mechanism 58 reduces an increase in resistance to the rotation of the crankshaft 46 caused by compression of air in the cylinder in the compression stroke of the engine. That is, the decompression mechanism 58 is a mechanism that opens the exhaust valve 52 at a predetermined timing in order to reduce the pressure in the cylinder in the compression stroke in starting the engine.

<Start Operation of Engine Unit>

[0077] First, a torque necessary for cranking in starting the engine will be described. FIG. 2 is an illustration showing a relationship between a crank angle and a torque necessary for cranking in starting the engine.

[0078] The engine 10 of the engine unit 100 includes, in four strokes, a high-load region TH where a load for rotating the crankshaft 46 is high and a low-load region TL where the load for rotating the crankshaft 46 is lower than the load in the high-load region TH. In the crank angle of the crankshaft 46, the low-load region TL is equal to or wider than the high-load region TH. More specifically, the low-load region TL is wider than the high-load region TH. In other words, a rotation angle region corresponding to the low-load region TL is wider than a rotation angle region corresponding to the high-load region TH.

[0079] More specifically, the engine 10 repeats four strokes of the intake stroke, the compression stroke, the expansion stroke, and the exhaust stroke. As illustrated in FIG. 2, the compression stroke is included in the high-load region TH but is not included in the low-load region TL. In the engine 10 according to this embodiment, the high-load region TH is a region substantially overlapping the compression stroke, and the low-load region TL is a region substantially overlapping the intake stroke, the expansion stroke, and the exhaust stroke. It should be noted that the edge of each of the high-load region TH and the low-load region TL does not need to coincide with the edge of each of the strokes.

[0080] In the compression stroke, an air-fuel mixture in the combustion chamber 36 is compressed by the piston 42 so that a reaction force is generated by the compression. Thus, in the compression stroke, a torque necessary for cranking is larger than those in the other strokes. The decompression mechanism 58 is actuated in the compression stroke to thereby reduce the pressure in the combustion chamber 36.

[0081] The decompression mechanism 58 operates to open the exhaust valve 52 with a crank angle of around 630 degrees. A period in which the exhaust valve 52 is opened by the decompression mechanism 58 is a short period in the compression stroke. In addition, as illustrated in FIG. 6, the timing at which the exhaust valve 52 is opened by the decompression mechanism 58 is immediately before the intake valve 50 is closed or after the intake valve 50 is closed. As illustrated in FIG. 6, the timing when the exhaust valve 52 is opened by the decompression mechanism 58 is adjustable within the compression stroke. The valve lift amount of the exhaust valve 52 in an actuation period of the decompression mechanism 58 is smaller than the valve lift amount of the intake valve 50. The valve lift amount is a distance in which the valve moves away from the valve seat in an axial direction.

[0082] A start operation of the engine unit 100 will now be described. In this embodiment, in starting the engine 10, cranking is performed by the starter motor 30. The start of the engine 10 includes a case where the engine 10 starts from a state where the engine temperature is lower than a temperature in operation of the engine 10 and a case where the engine 10 starts again from an engine stopped state in an idling stop system. The idling stop system has a configuration similar to a known configuration, and thus, detailed description and illustration of the idling stop system will be omitted.

[0083] FIG. 3 is a flowchart depicting an operation of rotation speed control of the permanent magnet starter motor 30 by the ECU 32 in starting the engine unit 100. FIG. 4 is a graph showing a relationship between an engine speed and a crank angle in starting the engine unit 100. FIG. 5 is a view illustrating an example of a motion of the crankshaft 46 in starting the engine unit 100.

[0084] First, when the start switch 66 turns on and a startup request flag is set (step S1), the motor controller 73 of the ECU 32 drives and rotates the permanent magnet starter motor 30.

[0085] The engine 10 stops combustion by a combustion stop instruction by the ECU 32. The crankshaft 46 rotates with an inertial force after stopping of combustion in the engine 10. When the inertial force becomes smaller than a compression reaction force in the compression stroke of the engine 10, the crankshaft 46 rotates in the reverse direction by the compression reaction force and stops. Thus, as illustrated in FIG. 5, the stop position of the crankshaft 46 is often at a crank angle P0 of the intake stroke that is a stroke before the compression stroke.

[0086] Based on a signal output from the crank angle sensor 26, the ECU 32 acquires information on the crank angle and the rotation speed of the engine 10. In the case where the crank angle of the crankshaft 46 is not at a specified position, the motor controller 73 of the ECU 32 rotates the permanent magnet starter motor 30 in the reverse direction, as indicated by broken lines in FIGS. 4 and 5. The reverse rotation of the permanent magnet starter motor 30 continues until the crank angle reaches the specified position PI in the expansion stroke.

[0087] Subsequently, the crank angle determiner 71 of the ECU 32 determines whether the crank angle of the crankshaft 46 is larger than a predetermined angle or not (step S2). The predetermined angle is an angle smaller than a crank angle (specified angle) at which fuel injection occurs.

[0088] If the crank angle of the crankshaft 46 is larger than the predetermined angle (YES in step S2), the motor controller 73 of the ECU 32 controls driving of the permanent magnet starter motor 30 such that the rotation speed of the crankshaft 46 is a target rotation speed A (step S3). Control of the rotation speed of the permanent magnet starter motor 30 may be torque control using a duty ratio, or speed control in which feedback control is performed by detecting the rotation speed of the permanent magnet starter motor 30.

[0089] The upper limit of the target rotation speed A is a speed at which a fuel injection time obtained from the engine temperature measured by the engine temperature sensor 28 as described later can be obtained, and the lower limit of the target rotation speed A is a speed at which the engine can pass over a maximum load in the high-load region TH.

[0090] If the rotation speed of the crankshaft 46 is low, vaporized fuel cannot be compressed in the high-load region TH, and the engine 10 is stopped.

[0091] On the other hand, if the rotation speed of the crankshaft 46 is high, the time for evaporation of the injected fuel cannot be sufficiently obtained. In this case, a fuel concentration in the combustion chamber 36 of the engine 10 becomes insufficient, which might cause a failure in increasing the rotation speed of the engine 10 and an accidental fire, for example.

[0092] That is, when the rotation speed of the crankshaft 46 in cranking increases excessively, after a lapse of a fuel injection time FI (see FIG. 4), fuel is insufficiently evaporated in the passage 34a of the intake passage 33a. Consequently, an air-fuel ratio in the combustion chamber 36 is not an appropriate value in some cases.

[0093] The target rotation speed A of the crankshaft 46 is determined within the range between the upper and lower limits in consideration of the phenomenon as described above. The target rotation speed A is obtained based on the temperature of the engine 10, which will be described later.

[0094] If the crank angle of the crankshaft 46 is less than or equal to the predetermined angle (NO in step S2), the crank angle determiner 71 repeats the determination of step S2 until the crank angle of the crankshaft 46 exceeds the predetermined angle.

[0095] After the permanent magnet starter motor 30 is driven and controlled at the target rotation speed A, the crank angle determiner 71 determines whether the crank angle of the crankshaft 46 is larger than a specified angle at which fuel injection starts (step S4). If the crank angle of the crankshaft 46 is larger than the specified angle for fuel injection start (YES in step S4), the fuel injection controller 74 of the ECU 32 causes the fuel injection device 54 to inject fuel (step S5). On the other hand, if the crank angle of the crankshaft 46 is less than or equal to the specified angle for fuel injection start (NO in step S4), the determination of step S4 is repeated until the crank angle of the crankshaft 46 exceeds the specified angle for fuel injection start.

[0096] In this embodiment, the specified angle for fuel injection start by fuel injection device 54 is, for example, 300°. Alternatively, the specified angle for fuel injection start may be an angle other than 300°. As described above, the fuel injection time is determined by the fuel injection time determiner 72 based on injection time data previously determined based on an engine temperature. The injection time data is stored in the memory 76 of the ECU 32. Fuel injection needs to be finished within a period from when fuel injection starts to when the intake valve 50 is closed (within a period FI shown in FIG. 4) at the latest.

[0097] After fuel injection has started by the fuel injection device 54, the fuel injection time determiner 72 of the ECU 32 determines whether the cumulative fuel injection time as a cumulative time of fuel injection is larger than a default value (predetermined time) of the fuel injection time or not (step S6). If the cumulative fuel injection time is determined to be larger than the default value (YES in step S6), fuel injection by the fuel injection device 54 is stopped (step S7). Thereafter, rotation speed control in which the target rotation speed has been set at A in step S3 is canceled (step S8), and a flow of the rotation speed control in starting the engine is finished (end). The default value is determined depending on the engine temperature by using injection time data.

[0098] On the other hand, if the cumulative fuel injection time is determined to be less than or equal to the default value (NO in step S6), fuel injection by the fuel injection device 54 continues until the cumulative fuel injection time exceeds the default value.

[0099] After the rotation speed control of the permanent magnet starter motor 30 by the ECU 32 described above, when the intake valve 50 is closed, in the following compression stroke, the compressed pressure in the combustion chamber 36 serves as a rotation load of the crankshaft 46. Thus, as shown in FIG. 4, the rotation speed of the crankshaft 46 decreases. After the crankshaft 46 has passed through a position corresponding to a compression top dead point in the compression stroke, the ignition controller 75 of the ECU 32 causes the ignition plug 56 to ignite an air-fuel mixture in the combustion chamber 36 so that initial combustion occurs. In this embodiment, the crank angle at ignition of the ignition plug 56 is 715 degrees, but is not limited to this example.

[0100] With the initial combustion, a rotary force is exerted on the crankshaft 46, and the strokes in the four cycles are intermittently performed in the engine 10 so that start of the engine 10 by cranking is completed.

<Determination Procedure of Target Rotation Speed>

[0101] Next, a procedure of determining the target rotation speed A of the crankshaft 46 in starting the engine 10 will be described.

[0102] Based on the temperature of the engine 10 measured by the engine temperature sensor 28, the fuel injection time determiner 72 of the ECU 32 refers to injection time data previously stored in the memory 76 of the ECU 32, and determines a fuel injection time for the first combustion in starting the engine 10.

[0103] The injection time data is, for example, a table in which an engine temperature is associated with the fuel injection time. The injection time data is set such that the fuel injection time increases as the engine temperature decreases. The injection time may be calculated such that the injection time increases with a decrease in temperature in accordance with a predetermined relational expression, or may be set such that the injection time is constant within a predetermined range and decreases when the engine temperature increases across the predetermined range. An example of the injection time is indicated by solid arrow in FIG. 2. As shown in FIG. 2, the injection time at an engine temperature of -5°C is longer than the injection time at an engine temperature of 80°C. FIG. 2 shows only a first stroke for the injection time and does not show the subsequent strokes.

[0104] The injection time data varies depending on the position to which the fuel injection device 54 injects fuel, the injection direction, and the size of liquid droplets of the injected fuel. This is performed in order to obtain an appropriate air-fuel ratio at ignition by sufficiently evaporating the injected fuel even at low temperatures of the engine 10. Thus, the injection time data is set such that the fuel injection time is long at a low engine temperature. In general, the injection time decreases as the size of liquid droplets of the injected fuel decreases and the expansion angle of spraying increases.

[0105] The fuel injection by the fuel injection device 54 starts at a predetermined crank angle (e.g., 300 degrees), and finishes until the intake valve 50 is closed in the intake stroke of the engine 10. Thus, the rotation speed of the crankshaft 46 needs to be determined such that the fuel injection finishes before the intake valve 50 is closed. In this embodiment, the timing of fuel injection start is fixed at a crank angle of 300 degrees, independently of the engine temperature.

[0106] Accordingly, to obtain a fuel injection time at low temperatures, the target rotation speed A of the crankshaft 46 needs to be set depending on the time from the fuel injection start to closing of the intake valve 50. Thus, as shown in FIG. 7, as the injection time increases, the target rotation speed A is set lower. As described above, the fuel injection time needs to be increased as the engine temperature decreases. Thus, as shown in FIG. 7, a target rotation speed A' at a low engine temperature is lower than the target rotation speed A at a high engine temperature.

[0107] FIG. 8A shows an example of a relationship between an engine temperature and a rotation speed of the crankshaft 46 in starting the engine. As described above, the target rotation speed A of the crankshaft 46 decreases as the temperature of the engine 10 decreases. As an example, as shown in FIG. 8A, in temperatures of the engine 10 at any two points on the graph (referred to as a first temperature and a second temperature, respectively), the ECU 32 controls the rotation speed of the permanent magnet starter motor 30 such that the rotation speed of the crankshaft 46 at the relatively low first temperature is lower than the rotation speed at the second temperature higher than the first temperature.

[0108] The rotation speed of the crankshaft 46 does not continuously change in accordance with the temperature of the engine 10 as described above, but as shown in FIG. 8B, control may be performed such that the temperature of the engine 10 is constant to a predetermined temperature and when the temperature of the engine 10 decreases below the predetermined temperature, the rotation speed is reduced.

[0109] As described above, the fuel injection only needs to be finished within a period from when the fuel injection starts to when the intake valve 50 is closed (fuel injection time FI). Thus, the fuel injection time of the injection time data may be shorter than the fuel injection time FI.

[0110] When the target rotation speed of the crankshaft 46 is increased in accordance with the fuel injection time, power consumption of the permanent magnet starter motor 30 increases, and accordingly, power consumption of the battery 64 increases. On the other hand, the target rotation speed A of the crankshaft 46 may be reduced to a rotation speed at which a necessary fuel injection time can be obtained in accordance with the engine temperature. This can reduce power consumption of the permanent magnet starter motor 30 so that an increase in power consumption of the battery 64 can be suppressed.

[0111] In the engine unit 100 according to this embodiment, the permanent magnet starter motor 30 that can obtain a higher output torque at a lower rotation speed is used as a starter motor. In addition, in the engine 10 in which the high-load region TH and the low-load region TL are present in four strokes, as shown in FIG. 5, in the low-load region TL after the crankshaft 46 rotates from the stopped state to the first combustion, the target rotation speed A of the crankshaft 46 is set in accordance with the engine temperature. Thus, a time for vaporization of fuel supplied into the intake passage 33a can be obtained. As a result, energy obtained by the first combustion can be sufficiently increased so that startability of the engine 10 can be enhanced.

[0112] In this embodiment, the decompression mechanism 58 is actuated in the compression stroke in starting the engine so that the pressure in the combustion chamber 36 can be reduced. However, the actuation of the decompression mechanism 58 in the compression stroke might cause the possibility that sufficient energy cannot be obtained in the first compression in starting the engine so that the rotation speed of the crankshaft 46 cannot be increased. On the other hand, in the engine unit 100 according to this embodiment, in the low-load region TL after the rotation of the crankshaft 46 from the stopped state to the first combustion, the target rotation speed A of the crankshaft 46 is set in accordance with the engine temperature so that the time for vaporization of fuel supplied into the intake passage 33a can be obtained. Thus, energy obtained by the first combustion can be sufficiently enhanced, and as a result, startability of the engine 10 can be enhanced.

Second Embodiment

[0113] FIG. 10 is a schematic view illustrating a configuration of an engine unit 101 according to the second embodiment. The engine unit 101 according to this embodiment is different from the engine unit 100 according to the first embodiment in that an ECU 80 sets a rotation speed of the crankshaft 46 in accordance with the temperature of the engine 10 by using rotation speed data as map data of the engine temperature and a target rotation speed A.

[0114] Specifically, the ECU 80 includes a rotation speed calculator 70, a crank angle determiner 71, a motor controller 73, a fuel injection controller 74, an ignition controller 75, a memory 76, and a rotation speed determiner 81.

[0115] In this embodiment, the memory 76 stores rotation speed data as map data in which the temperature of the engine 10 and the target rotation speed A of the crankshaft 46 in starting the engine are associated with each other beforehand, in addition to injection time data similar to that in the first embodiment.

[0116] The rotation speed determiner 81 determines, by using the rotation speed data stored in the memory 76, the target rotation speed A of the crankshaft 46 in starting the engine in accordance with an engine temperature measured by the engine temperature sensor

28. The motor controller 73 controls an inverter 62 by using the target rotation speed A determined by the rotation speed determiner 81 to thereby drive a permanent magnet starter motor 30 such that the crankshaft 46 reaches the target rotation speed A.

[0117] The fuel injection controller 74 determines, by using the rotation speed data stored in the memory 76, a fuel injection time in accordance with the engine temperature measured by the engine temperature sensor 28. The method for determining the fuel injection time is similar to that in the first embodiment. The fuel injection time may be determined in accordance with the rotation speed of the crankshaft 46.

[0118] Part of the configuration of the ECU 80 except for the configuration described above is similar to that of the ECU 32 of the first embodiment, and detailed description of the ECU 80 will be omitted.

[0119] The configuration of this embodiment can also obtain the time for vaporization of fuel supplied into an intake passage 33a. As a result, energy obtained by the first combustion can be sufficiently increased so that startability of the engine 10 can be enhanced.

Other Embodiments

[0120] The embodiments described above have been directed to the engine units using single-cylinder four-stroke engines. The engines, however, may be parallel-twin cylinder or a V-twin cylinder four-stroke engine.

[0121] The embodiments described above have been directed to the case where the crankshaft 46 rotates in the reverse direction in starting the engine. However, the present teaching is not limited to these embodiments, and the crankshaft 46 may not rotate in the reverse direction and may rotate in the normal direction in starting the engine.

[0122] The permanent magnet starter motor 30 used in each embodiment may be a motor with a brush or a brushless motor. The starter motor may be a starter motor generator also serving as an electric generator.

[0123] In the embodiments described above, the fuel injection device 54 injects fuel toward the intake valve 50, but may inject fuel toward another position in the intake passage 33a. For example, the fuel injection device 54 may inject fuel toward a position upstream of the intake valve 50 and located on an inner surface of the wall constituting the intake passage 33a.

[0124] In this case, the injection time data can be set such that the injection time is longer than that in the case of injecting fuel toward the intake valve 50. That is, as shown in FIG. 11, a target rotation speed A of the crankshaft 46 in the case of injecting fuel toward the inner surface of the wall constituting the intake passage 33a is lower than that in the case of injecting fuel toward the intake valve 50.

[0125] The embodiments described above are directed to the configurations in which the engine units 100 and 101 are applied to motorcycles. Alternatively, the engine units 100 and 101 may be applied to other vehicles such as tricycles or four-wheel vehicles.

[0126] In the embodiments described above, the temperature of an engine coolant is measured as the temperature of the engine 10. In the case of an air cooling engine, for example, the temperature of oil in an oil passage in which lubricating oil flows may be measured as the temperature of the engine.

[0127] Although the engine 10 uses the TPS 22 in the above embodiments, the engine 10 may use an accelerator position sensor instead of the TPS 22.

[0128] In the first embodiment, the engine unit 100 includes the decompression mechanism 58. The engine unit 101 in the second embodiment may also include a decompression mechanism. The engine unit 100 may not include a decompression mechanism.

DESCRIPTION OF REFERENCE CHARACTERS

[0129]

10 four-stroke engine body
12 air cleaner
14a, 14b intake pipe
16 exhaust pipe
20 throttle device
22 TPS
24 pressure sensor
26 crank angle sensor (crank angle detector)
28 engine temperature sensor (engine temperature detector)
30 permanent magnet starter motor
32, 80 ECU (control device)
33a intake passage
33b exhaust passage
35a intake port
35b exhaust port
34 cylinder head
36 combustion chamber
40 cylinder
42 piston
44 crankcase
46 crankshaft
48 connecting rod
50 intake valve
52 exhaust valve
54 fuel injection device
56 ignition plug (ignition device)
58 decompression mechanism
62 inverter
64 battery
66 start switch
70 rotation speed calculator
71 crank angle determiner
72 fuel injection time determiner
73 motor controller
74 fuel injection time controller
75 ignition controller

76 memory
81 rotation speed determiner
100, 101 engine unit

Claims

1. An engine unit (100,101) comprising:

a four-stroke engine body (10) including
a combustion chamber (36) having an intake port (35a) and an exhaust port (35b),
an intake valve (50) configured to open and close the intake port (35a),
an exhaust valve (52) configured to open and close the exhaust port (35b),
an intake passage (33a) connected to the intake port (35a) and configured to guide air in the atmosphere into the combustion chamber (36) through the intake port (35a),
an exhaust passage (33b) connected to the exhaust port (35b),
a fuel injection device (54) configured to inject fuel into the intake passage (33a),
an ignition device (56) configured to ignite an air-fuel mixture including fuel and air in the combustion chamber (36),
a piston (42) configured to move to and fro in the combustion chamber (36), and
a crank shaft (46) connected to the piston (42) to rotate in accordance with the to-and-fro movement of the piston (42), wherein
a high-load region (TH) where a load for rotating the crank shaft (46) is high and a low-load region (TL) where a load for rotating the crank shaft (46) is lower than the load in the high-load region (TH) being present in four strokes;
a permanent magnet starter motor (30) that includes a permanent magnet and is configured to rotate the crank shaft (46);
a control device (32) that is configured to control the permanent magnet starter motor (30), the fuel injection device (54), and the ignition device (56);
an engine temperature detector (28) that is configured to detect a temperature of the four-stroke engine body (10); and
a crank angle detector (26) that is configured to detect a crank angle, the crank angle being a position of a rotation angle of the crank shaft (46), wherein
the control device (32) is configured to
drive the permanent magnet starter motor (30) to rotate the crank shaft (46) from a suspended state,
control the fuel injection device (54) while a crank angle of the crank shaft (46) is in the low-load region (TL), thereby injecting fuel into the intake passage (33a),
control a rotation speed of the permanent magnet starter motor (30) so that an increase in a rotation speed of the crank shaft (46) is suppressed and the time for vaporization of fuel is obtained, based on the temperature of the four-stroke engine body (10) detected by the engine temperature detector (28) while the crank angle of the crank shaft (46) is in the low-load region (TL) and from when the fuel injection device (54) injects fuel into the intake passage (33a) to when the intake valve (50) is closed, and
start the four-stroke engine body (10) by igniting the air-fuel mixture in the combustion chamber (36) by using the ignition device (56) while the crank angle of the crank shaft (46) is in the high-load region (TH).

2. The engine unit (100,101) according to claim 1, wherein the control device (32) is configured to control the rotation speed of the permanent magnet starter motor (30) such that a rotation speed of the crank shaft (46) obtained when the temperature of the four-stroke engine body (10) detected by the engine temperature detector (28) is a first temperature is lower than a rotation speed of the crank shaft (46) obtained when the temperature of the four-stroke engine body (10) detected by the engine temperature detector (28) is a second temperature higher than the first temperature.

3. The engine unit (100,101) according to claim 1 or 2, wherein the fuel injection device (54) is configured to inject fuel toward the intake valve (50).

4. The engine unit (100,101) according to any one of claims 1 to 3, wherein the control device (32) is configured to determine a rotation speed of the crank shaft (46) in accordance with a fuel injection time determined based on the temperature of the four-stroke engine body (10) detected by the engine temperature detector (28).

5. The engine unit (100,101) according to any one of claims 1 to 4, wherein the engine temperature detector is a sensor (28) that is configured to detect a temperature of a coolant of the four-stroke engine body (10) or a temperature of oil in an oil passage.

6. The engine unit (100,101) according to any one of claims 1 to 5, wherein the control device (32) is configured to cause the fuel injection device (54) to inject fuel until the fuel injection time exceeds a predetermined time in which fuel necessary for engine start is allowed to be supplied.

7. The engine unit (100,101) according to any one of claims 1 to 6, wherein the control device (32) is con-

figured to control the rotation speed of the motor such that as the temperature of the four-stroke engine body (10) detected by the engine temperature detector (28) decreases, the rotation speed of the crank shaft (46) in the fuel injection time decreases.

8. The engine unit (100,101) according to any one of claims 1 to 7, wherein the four-stroke engine body (10) further includes a decompression mechanism (58) that is configured to temporarily open the exhaust valve (52) in order to eject the air-fuel mixture in the combustion chamber (36) while the crank angle of the crank shaft (46) is in the high-load region (TH).

9. A method for controlling an engine unit (100,101) having a four-stroke engine body (10) with a combustion chamber (36) having an intake port (35a) and an exhaust port (35b), an intake valve (50) configured to open and close the intake port (35a), an exhaust valve (52) configured to open and close the exhaust port (35b), an intake passage (33a) connected to the intake port (35a) and configured to guide air in the atmosphere into the combustion chamber (36) through the intake port (35a), an exhaust passage (33b) connected to the exhaust port (35b), a fuel injection device (54) configured to inject fuel into the intake passage (33a), an ignition device (56) configured to ignite an air-fuel mixture including fuel and air in the combustion chamber (36), a piston (42) configured to move to and fro in the combustion chamber (36), and a crank shaft (46) connected to the piston (42) to rotate in accordance with the to-and-fro movement of the piston (42), wherein a high-load region (TH) where a load for rotating the crank shaft (46) is high and a low-load region (TL) where a load for rotating the crank shaft (46) is lower than the load in the high-load region (TH) being present in four strokes, a permanent magnet starter motor (30) that includes a permanent magnet and is configured to rotate the crank shaft (46), the method comprises:

detecting a temperature of the four-stroke engine body (10) by an engine temperature detector (28); and
detecting a crank angle by a crank angle detector (26), the crank angle being a position of a rotation angle of the crank shaft (46),
driving the permanent magnet starter motor (30) to rotate the crank shaft (46) from a suspended state,
controlling the fuel injection device (54) while a crank angle of the crank shaft (46) is in the low-load region (TL), thereby injecting fuel into the intake passage (33a),
controlling a rotation speed of the permanent magnet starter motor (30) so that an increase in a rotation speed of the crank shaft (46) is suppressed and the time for
vaporization of fuel is obtained, based on the temperature of the four-stroke engine body (10) detected by the engine temperature detector (28) while the crank angle of the crank shaft (46) is in the low-load region (TL) and from when the fuel injection device (54) injects fuel into the intake passage (33a) to when the intake valve (50) is closed, and
starting the four-stroke engine body (10) by igniting the air-fuel mixture in the combustion chamber (36) by using the ignition device (56) while the crank angle of the crank shaft (46) is in the high-load region (TH).

10. The method for controlling an engine unit (100,101) according to claim 9, further comprising:
controlling the rotation speed of the permanent magnet starter motor (30) such that a rotation speed of the crank shaft (46) obtained when the temperature of the four-stroke engine body (10) detected by the engine temperature detector (28) is a first temperature is lower than a rotation speed of the crank shaft (46) obtained when the temperature of the four-stroke engine body (10) detected by the engine temperature detector (28) is a second temperature higher than the first temperature.

11. The method for controlling an engine unit (100,101) according to claim 9 or 10, further comprising:
determining a rotation speed of the crank shaft (46) in accordance with a fuel injection time determined based on the temperature of the four-stroke engine body (10) detected by the engine temperature detector (28).

12. The method for controlling an engine unit (100,101) according to any one of claims 9 to 11, further comprising:
causing the fuel injection device (54) to inject fuel until the fuel injection time exceeds a predetermined time in which fuel necessary for engine start is allowed to be supplied.

13. The method for controlling an engine unit (100,101) according to any one of claims 9 to 12, further comprising:
controlling the rotation speed of the motor such that as the temperature of the four-stroke engine body (10) detected by the engine temperature detector (28) decreases, the rotation speed of the crank shaft (46) in the fuel injection time decreases.

Patentansprüche

1. Eine Motor-Einheit (100, 101), die umfasst:

einem Viertakt-Motor-Körper (10), der beinhaltet
einer Brenn-Kammer (36), die einen Einlass-Anschluss (35a) und einen Auslass-Anschluss (35b) hat,
ein Einlass-Ventil (50), das konfiguriert ist, um den Einlass-Anschluss (35a) zu öffnen und zu schließen,
ein Auslass-Ventil (52), das konfiguriert ist, um den Auslass-Anschluss (35b) zu öffnen und zu schließen,
einen Einlass-Durchgang (33a), der mit dem Einlass-Anschluss (35a) verbunden ist,
und konfiguriert ist, um Luft in der Atmosphäre in die Brenn-Kammer (36) durch den Einlass-Anschluss (35a) zu leiten,
einen Auslass-Durchgang (33b), der mit des Auslass-Anschluss (35b) verbunden ist,
eine Kraftstoff-Einspritz-Vorrichtung (54), die konfiguriert ist, um Kraftstoff in den Einlass-Durchgang (33a) einzuspritzen,
eine Zünd-Vorrichtung (56), die konfiguriert ist, um ein Luft-Kraftstoff-Gemisch, das Kraftstoff und Luft enthält, in der Brenn-Kammer (36) zu zünden,
einen Kolben (42), der konfiguriert ist, um sich in der Brenn-Kammer (36) hin und her zu bewegen, und
eine Kurbel-Welle (46), die mit dem Kolben (42) verbunden ist, um sich in Übereinstimmung mit der Hin- und Her-Bewegung des Kolbens (42) zu drehen, wobei ein Hoch-Last-Bereich (TH), in dem eine Last zum Drehen der Kurbel-Welle (46) hoch ist, und einen Niedrig-Last-Bereich (TL), in dem eine Last zum Drehen der Kurbel-Welle (46) niedriger ist als die Last in dem Hoch-Last-Bereich (TH), in vier Hüben vorhanden ist;
einen Permanent-Magnet-Starter-Motor (30), der einen Permanent-Magneten enthält und konfiguriert ist, um die Kurbel-Welle (46) zu drehen;
eine Steuer-Vorrichtung (32), die konfiguriert ist, um den Permanent-Magnet-Starter-Motor (30), die Kraftstoff-Einspritz-Vorrichtung (54) und die Zünd-Vorrichtung (56) zu steuern;
einen Motor-Temperatur-Detektor (28), der konfiguriert ist, um eine Temperatur des Viertakt-Motor-Körpers (10) zu erfassen; und
einen Kurbel-Winkel-Detektor (26), der konfiguriert ist, um einen Kurbel-Winkel zu erfassen, wobei der Kurbel-Winkel eine Position eines Dreh-Winkels der Kurbel-Welle (46) ist, wobei
die Steuer-Vorrichtung (32) ist konfiguriert, um den Permanent-Magnet-Starter-Motor (30) anzutreiben, um die Kurbel-Welle (46) aus einem ausgesetzten Zustand heraus zu drehen,
die Kraftstoff-Einspritz-Vorrichtung (54) zu steuern, während ein Kurbel-Winkel der Kurbel-Welle (46) in dem Niedrig-Last-Bereich (TL) ist, wodurch Kraftstoff in den Einlass-Durchgang (33a) eingespritzt wird,
Steuern einer Dreh-Geschwindigkeit des Permanent-Magnet-Starter-Motors (30), so dass ein Anstieg einer Dreh-Geschwindigkeit der Kurbel-Welle (46) unterdrückt wird und die Zeit für die Verdampfung von Kraftstoff erhalten wird, basierend auf der Temperatur des Viertakt-Motor-Körpers (10), die von dem Motor-Temperatur-Detektor (28) erfasst wird, während sich der Kurbel-Winkel der Kurbel-Welle (46) in dem Niedrig-Last-Bereich (TL) befindet und von dem Zeitpunkt, an dem die Kraftstoff-Einspritz-Vorrichtung (54) Kraftstoff in den Einlass-Durchgang (33a) einspritzt, bis zu dem Zeitpunkt, an dem das Einlass-Ventil (50) geschlossen ist, und
Starten des Viertakt-Motor-Körpers (10) durch Zünden des Luft-Kraftstoff-Gemisches in der Brenn-Kammer (36) unter Verwendung der Zünd-Vorrichtung (56), während sich der Kurbel-Winkel der Kurbel-Welle (46) in dem Hoch-Last-Bereich (TH) befindet.

2. Die Motor-Einheit (100, 101) gemäß Anspruch 1, wobei die Steuer-Vorrichtung (32) konfiguriert ist, um die Dreh-Geschwindigkeit des Permanent-Magnet-Starter-Motors (30) zu steuert, so dass eine Dreh-Geschwindigkeit der Kurbel-Welle (46), die erhalten wird, wenn die Temperatur des Viertakt-Motor-Körpers (10), die von dem Motor-Temperatur-Detektor (28) erfasst ist, eine erste Temperatur ist, niedriger ist als eine Dreh-Geschwindigkeit der Kurbel-Welle (46), die erhalten wird, wenn die Temperatur des Viertakt-Motor-Körpers (10), dei von dem Motor-Temperatur-Detektor (28) erfasst ist, eine zweite Temperatur ist, die höher als die erste Temperatur ist.

3. Die Motor-Einheit (100, 101) gemäß Anspruch 1 oder 2, wobei die Kraftstoff-Einspritz-Vorrichtung (54) konfiguriert ist, um Kraftstoff in Richtung des Einlass-Ventils (50) einzuspritzen.

4. Die Motor-Einheit (100, 101) gemäß irgendeinem der Ansprüche 1 bis 3, wobei die Steuer-Vorrichtung (32) konfiguriert ist, um eine Dreh-Geschwindigkeit der Kurbel-Welle (46) in Übereinstimmung mit einer Kraftstoff-Einspritz-Zeit zu bestimmen, die auf der Grundlage der Temperatur des Viertakt-Motor-Körpers (10), die von dem Motor-Temperatur-Detektor (28) erfasst ist, bestimmt ist.

5. Die Motor-Einheit (100, 101) gemäß irgendeinem der Ansprüche 1 bis 4, wobei der Motor-Temperatur-Detektor ein Sensor (28) ist, der konfiguriert ist, um eine Temperatur eines Kühlmittels des Viertakt-Mo-

tor-Körpers (10) oder eine Temperatur von Öl in einem Öl-Durchgang zu erfassen.

6. Die Motor-Einheit (100, 101) gemäß irgendeinem der Ansprüche 1 bis 5, wobei die Steuer-Vorrichtung (32) konfiguriert ist, um die Kraftstoff-Einspritz-Vorrichtung (54) zu veranlassen, Kraftstoff einzuspritzen, bis die Kraftstoff-Einspritz-Zeit eine vorbestimmte Zeit überschreitet, in der Kraftstoff, der für den Motorstart notwendig ist, zugeführt werden darf.

7. Die Motor-Einheit (100, 101) gemäß irgendeinem der Ansprüche 1 bis 6, wobei die Steuer-Vorrichtung (32) konfiguriert ist, um die Dreh-Geschwindigkeit des Motors zu steuern, so dass, wenn die Temperatur des Viertakt-Motor-Körpers (10), die von dem Motor-Temperatur-Detektor (28) erfasst ist, abnimmt, die Dreh-Geschwindigkeit der Kurbel-Welle (46) in der Kraftstoff-Einspritz-Zeit abnimmt.

8. Die Motor-Einheit (100, 101) gemäß irgendeinem der Ansprüche 1 bis 7, wobei der Viertakt-Motor-Körper (10) ferner einen Dekompressions-Mechanismus (58) enthält, der konfiguriert ist, um das Auslass-Ventil (52) vorübergehend zu öffnen, um das Luft-Kraftstoff-Gemisch in der Brenn-Kammer (36) auszustoßen, während der Kurbel-Winkel der Kurbel-Welle (46) in dem Hoch-Last-Bereich (TH) ist.

9. Verfahren zum Steuern einer Motor-Einheit (100, 101), die einen Viertakt-Motor-Körper (10) hat, mit einer Brenn-Kammer (36), die einen Einlass-Anschluss (35a) und einen Auslass-Anschluss (35b) hat, ein Einlass-Ventil (50), das konfiguriert ist, um den Einlass-Anschluss (35a) zu öffnen und zu schließen, ein Auslass-Ventil (52), das konfiguriert ist, um den Auslass-Anschluss (35b) zu öffnen und zu schließen, einen Einlass-Durchgang (33a), der mit dem Einlass-Anschluss (35a) verbunden ist, und konfiguriert ist, um Luft in der Atmosphäre in die Brenn-Kammer (36) durch den Einlass-Anschluss (35a) zu leiten, einen Auslass-Durchgang (33b), der mit des Auslass-Anschluss (35b) verbunden ist, eine Kraftstoff-Einspritz-Vorrichtung (54), die konfiguriert ist, um Kraftstoff in den Einlass-Durchgang (33a) einzuspritzen, eine Zünd-Vorrichtung (56), die konfiguriert ist, um ein Luft-Kraftstoff-Gemisch, das Kraftstoff und Luft enthält, in der Brenn-Kammer (36) zu zünden, einen Kolben (42), der konfiguriert ist, um sich in der Brenn-Kammer (36) hin und her zu bewegen, und eine Kurbel-Welle (46), die mit dem Kolben (42) verbunden ist, um sich in Übereinstimmung mit der Hin- und Her-Bewegung des Kolbens (42) zu drehen, wobei ein Hoch-Last-Bereich (TH), in dem eine Last zum Drehen der Kurbel-Welle (46) hoch ist, und einen Niedrig-Last-Bereich (TL), in dem eine Last zum Drehen der Kurbel-Welle (46) niedriger ist als die Last in dem Hoch-Last-Bereich (TH), in vier Hüben vorhanden ist, einen Permanent-Magnet-Starter-Motor (30), der einen Permanent-Magneten enthält und konfiguriert ist, um die Kurbel-Welle (46) zu drehen, das Verfahren umfasst:

Erfassen einer Temperatur des Viertakt-Motor-Körpers (10) durch einen Motor-Temperatur-Detektor (28), und
Erfassen eines Kurbel-Winkels durch einen Kurbel-Winkel-Detektor (26), der Kurbel-Winkel eine Position eines Dreh-Winkels der Kurbel-Welle (46) ist,
Antreiben des Permanent-Magnet-Starter-Motors (30), um die Kurbel-Welle (46) aus einem ausgesetzten Zustand heraus zu drehen,
Steuern der Kraftstoff-Einspritz-Vorrichtung (54), während ein Kurbel-Winkel der Kurbel-Welle (46) in dem Niedrig-Last-Bereich (TL) ist, wodurch Kraftstoff in den Einlass-Durchgang (33a) eingespritzt wird,
Steuern einer Dreh-Geschwindigkeit des Permanent-Magnet-Starter-Motors (30), so dass ein Anstieg einer Dreh-Geschwindigkeit der Kurbel-Welle (46) unterdrückt wird und die Zeit für die Verdampfung von Kraftstoff erhalten wird, basierend auf der Temperatur des Viertakt-Motor-Körpers (10), die von dem Motor-Temperatur-Detektor (28) erfasst wird, während sich der Kurbel-Winkel der Kurbel-Welle (46) in dem Niedrig-Last-Bereich (TL) befindet und von dem Zeitpunkt, an dem die Kraftstoff-Einspritz-Vorrichtung (54) Kraftstoff in den Einlass-Durchgang (33a) einspritzt, bis zu dem Zeitpunkt, an dem das Einlass-Ventil (50) geschlossen ist, und
Starten des Viertakt-Motor-Körpers (10) durch Zünden des Luft-Kraftstoff-Gemisches in der Brenn-Kammer (36) unter Verwendung der Zünd-Vorrichtung (56), während sich der Kurbel-Winkel der Kurbel-Welle (46) in dem Hoch-Last-Bereich (TH) befindet.

10. Das Verfahren zur Steuerung einer Motor-Einheit (100, 101) gemäß Anspruch 9, das ferner umfasst: Steuern der Dreh-Geschwindigkeit des Permanent-Magnet-Starter-Motors (30), so dass eine Dreh-Geschwindigkeit der Kurbel-Welle (46), die erhalten wird, wenn die Temperatur des Viertakt-Motor-Körpers (10), die von dem Motor-Temperatur-Detektor (28) erfasst ist, eine erste Temperatur ist, niedriger ist als eine Dreh-Geschwindigkeit der Kurbel-Welle (46), die erhalten wird, wenn die Temperatur des Viertakt-Motor-Körpers (10), dei von dem Motor-Temperatur-Detektor (28) erfasst ist, eine zweite Temperatur ist, die höher als die erste Temperatur ist.

11. Das Verfahren zur Steuerung einer Motor-Einheit

(100, 101) gemäß Anspruch 9 oder 10, das ferner umfasst:
Bestimmen einer Dreh-Geschwindigkeit der Kurbel-Welle (46) in Übereinstimmung mit einer Kraftstoff-Einspritz-Zeit, die auf der Grundlage der Temperatur des Viertakt-Motor-Körpers (10), die von dem Motor-Temperatur-Detektor (28) erfasst ist, bestimmt ist.

12. Das Verfahren zur Steuerung einer Motor-Einheit (100, 101) gemäß irgendeinem der Ansprüche 9 bis 11, das ferner umfasst:
Veranlassen der Kraftstoff-Einspritz-Vorrichtung (54), Kraftstoff einzuspritzen, bis die Kraftstoff-Einspritz-Zeit eine vorbestimmte Zeit überschreitet, in der Kraftstoff, der für den Motorstart notwendig ist, zugeführt werden darf.

13. Das Verfahren zur Steuerung einer Motor-Einheit (100, 101) gemäß irgendeinem der Ansprüche 9 bis 12, das ferner umfasst:
Steuern der Dreh-Geschwindigkeit des Motors, so dass, wenn die Temperatur des Viertakt-Motor-Körpers (10), die von dem Motor-Temperatur-Detektor (28) erfasst ist, abnimmt, die Dreh-Geschwindigkeit der Kurbel-Welle (46) in der Kraftstoff-Einspritz-Zeit abnimmt.

Revendications

1. Groupe moteur (100, 101) comprenant :

un corps de moteur à quatre temps (10) comportant
une chambre de combustion (36) ayant un orifice d'admission (35a) et un orifice d'échappement (35b),
une soupape d'admission (50) configurée pour ouvrir et fermer l'orifice d'admission (35a),
une soupape d'échappement (52) configurée pour ouvrir et fermer l'orifice d'échappement (35b),
un passage d'admission (33a) relié à l'orifice d'admission (35a) et configuré pour guider l'air dans l'atmosphère dans la chambre de combustion (36) à travers l'orifice d'admission (35a),
un passage d'échappement (33b) relié à l'orifice d'échappement (35b),
un dispositif d'injection de carburant (54) configuré pour injecter du carburant dans le passage d'admission (33a),
un dispositif d'allumage (56) configuré pour allumer un mélange air-carburant comportant du carburant et de l'air dans la chambre de combustion (36),
un piston (42) configuré pour se déplacer en va-et-vient dans la chambre de combustion (36), et
un vilebrequin (46) relié au piston (42) pour tourner conformément au mouvement de va-et-vient du piston (42), où
une région à charge élevée (TH) où une charge pour faire tourner le vilebrequin (46) est élevée et une région à faible charge (TL) où une charge pour faire tourner le vilebrequin (46) est inférieure à la charge dans la région à charge élevée (TH) étant présentes en quatre temps ;
un démarreur à aimant permanent (30) qui comporte un aimant permanent et est configuré pour faire tourner le vilebrequin (46) ;
un dispositif de commande (32) qui est configuré pour commander le démarreur à aimant permanent (30), le dispositif d'injection de carburant (54) et le dispositif d'allumage (56) ;
un détecteur de température de moteur (28) qui est configuré pour détecter une température du corps de moteur à quatre temps (10) ; et
un détecteur d'angle de vilebrequin (26) qui est configuré pour détecter un angle de vilebrequin, l'angle de vilebrequin étant une position d'un angle de rotation du vilebrequin (46), où
le dispositif de commande (32) est configuré pour
entraîner le démarreur à aimant permanent (30) pour faire tourner le vilebrequin (46) à partir d'un état suspendu,
commander le dispositif d'injection de carburant (54) tandis qu'un angle de vilebrequin du vilebrequin (46) se trouve dans la région à faible charge (TL), injectant ainsi du carburant dans le passage d'admission (33a),
commander une vitesse de rotation du démarreur à aimant permanent (30) de sorte qu'une augmentation de la vitesse de rotation du vilebrequin (46) soit supprimée et le temps de vaporisation du carburant soit obtenu, sur la base de la température du corps de moteur à quatre temps (10) détectée par le détecteur de température de moteur (28) tandis que l'angle de vilebrequin du vilebrequin (46) se trouve dans la région à faible charge (TL) et à partir du moment où le dispositif d'injection de carburant (54) injecte du carburant dans le passage d'admission (33a) jusqu'au moment où la soupape d'admission (50) est fermée, et
démarrer le corps de moteur à quatre temps (10) en allumant le mélange air-carburant dans la chambre de combustion (36) en utilisant le dispositif d'allumage (56) tandis que l'angle de vilebrequin du vilebrequin (46) se trouve dans la région à charge élevée (TH).

2. Groupe moteur (100, 101) selon la revendication 1, dans lequel le dispositif de commande (32) est configuré pour commander la vitesse de rotation du démarreur à aimant permanent (30) de sorte qu'une vitesse de rotation du vilebrequin (46) obtenue lorsque la température du corps de moteur à quatre temps (10) détectée par le détecteur de température de moteur (28) est une première température soit inférieure à une vitesse de rotation du vilebrequin (46) obtenue lorsque la température du corps de moteur à quatre temps (10) détectée par le détecteur de température de moteur (28) est une deuxième température supérieure à la première température.

3. Groupe moteur (100, 101) selon la revendication 1 ou 2, dans lequel le dispositif d'injection de carburant (54) est configuré pour injecter du carburant vers la soupape d'admission (50).

4. Groupe moteur (100, 101) selon l'une quelconque des revendications 1 à 3, dans lequel le dispositif de commande (32) est configuré pour déterminer une vitesse de rotation du vilebrequin (46) conformément à un temps d'injection de carburant déterminé sur la base de la température du corps de moteur à quatre temps (10) détectée par le détecteur de température de moteur (28).

5. Groupe moteur (100, 101) selon l'une quelconque des revendications 1 à 4, dans lequel le détecteur de température de moteur est un capteur (28) qui est configuré pour détecter une température d'un fluide de refroidissement du corps de moteur à quatre temps (10) ou une température d'huile dans un passage d'huile.

6. Groupe moteur (100, 101) selon l'une quelconque des revendications 1 à 5, dans lequel le dispositif de commande (32) est configuré pour amener le dispositif d'injection de carburant (54) à injecter du carburant jusqu'à ce que le temps d'injection de carburant dépasse un temps prédéterminé pendant lequel le carburant nécessaire au démarrage du moteur peut être fourni.

7. Groupe moteur (100, 101) selon l'une quelconque des revendications 1 à 6, dans lequel le dispositif de commande (32) est configuré pour commander la vitesse de rotation du moteur de sorte que, à mesure que la température du corps de moteur à quatre temps (10) détectée par le détecteur de température de moteur (28) diminue, la vitesse de rotation du vilebrequin (46), pendant le temps d'injection de carburant, diminue.

8. Groupe moteur (100, 101) selon l'une quelconque des revendications 1 à 7, dans lequel le corps de moteur à quatre temps (10) comporte en outre un mécanisme de décompression (58) qui est configuré pour ouvrir temporairement la soupape d'échappement (52) afin d'éjecter le mélange air-carburant dans la chambre de combustion (36) pendant que l'angle de vilebrequin du vilebrequin (46) se trouve dans la région à charge élevée (TH).

9. Procédé de commande d'un groupe moteur (100, 101) ayant un corps de moteur à quatre temps (10) avec une chambre de combustion (36) ayant un orifice d'admission (35a) et un orifice d'échappement (35b), une soupape d'admission (50) configurée pour ouvrir et fermer l'orifice d'admission (35a), une soupape d'échappement (52) configurée pour ouvrir et fermer l'orifice d'échappement (35b), un passage d'admission (33a) relié à l'orifice d'admission (35a) et configuré pour guider l'air dans l'atmosphère dans la chambre de combustion (36) à travers l'orifice d'admission (35a), un passage d'échappement (33b) relié à l'orifice d'échappement (35b), un dispositif d'injection de carburant (54) configuré pour injecter du carburant dans le passage d'admission (33a), un dispositif d'allumage (56) configuré pour allumer un mélange air-carburant comportant du carburant et de l'air dans la chambre de combustion (36), un piston (42) configuré pour se déplacer en va-et-vient dans la chambre de combustion (36), et un vilebrequin (46) relié au piston (42) pour tourner conformément au mouvement de va-et-vient du piston (42), où une région à charge élevée (TH) où une charge pour faire tourner le vilebrequin (46) est élevée et une région à faible charge (TL) où une charge pour faire tourner le vilebrequin (46) est inférieure à la charge dans la région à charge élevée (TH) étant présentes en quatre temps, un démarreur à aimant permanent (30) qui comporte un aimant permanent et est configuré pour faire tourner le vilebrequin (46), le procédé comprend :

détecter une température du corps de moteur à quatre temps (10) par un détecteur de température de moteur (28) ; et
détecter un angle de vilebrequin par un détecteur d'angle de vilebrequin (26), l'angle de vilebrequin étant une position d'un angle de rotation du vilebrequin (46),
entraîner le démarreur à aimant permanent (30) pour faire tourner le vilebrequin (46) à partir d'un état suspendu,
commander le dispositif d'injection de carburant (54) tandis qu'un angle de vilebrequin du vilebrequin (46) se trouve dans la région à faible charge (TL), injectant ainsi du carburant dans le passage d'admission (33a),
commander une vitesse de rotation du démarreur à aimant permanent (30) de sorte qu'une augmentation de la vitesse de rotation du vilebrequin (46) soit supprimée et le temps de vaporisation du carburant soit obtenu, sur la base de la température du corps de moteur à quatre temps (10) détectée par le détecteur de température de moteur (28) tandis que l'angle de vilebrequin du vilebrequin (46) se trouve dans la

région à faible charge (TL) et à partir du moment où le dispositif d'injection de carburant (54) injecte du carburant dans le passage d'admission (33a) jusqu'au moment où la soupape d'admission (50) est fermée, et
démarrer le corps de moteur à quatre temps (10) en allumant le mélange air-carburant dans la chambre de combustion (36) en utilisant le dispositif d'allumage (56) tandis que l'angle de vilebrequin du vilebrequin (46) se trouve dans la région à charge élevée (TH).

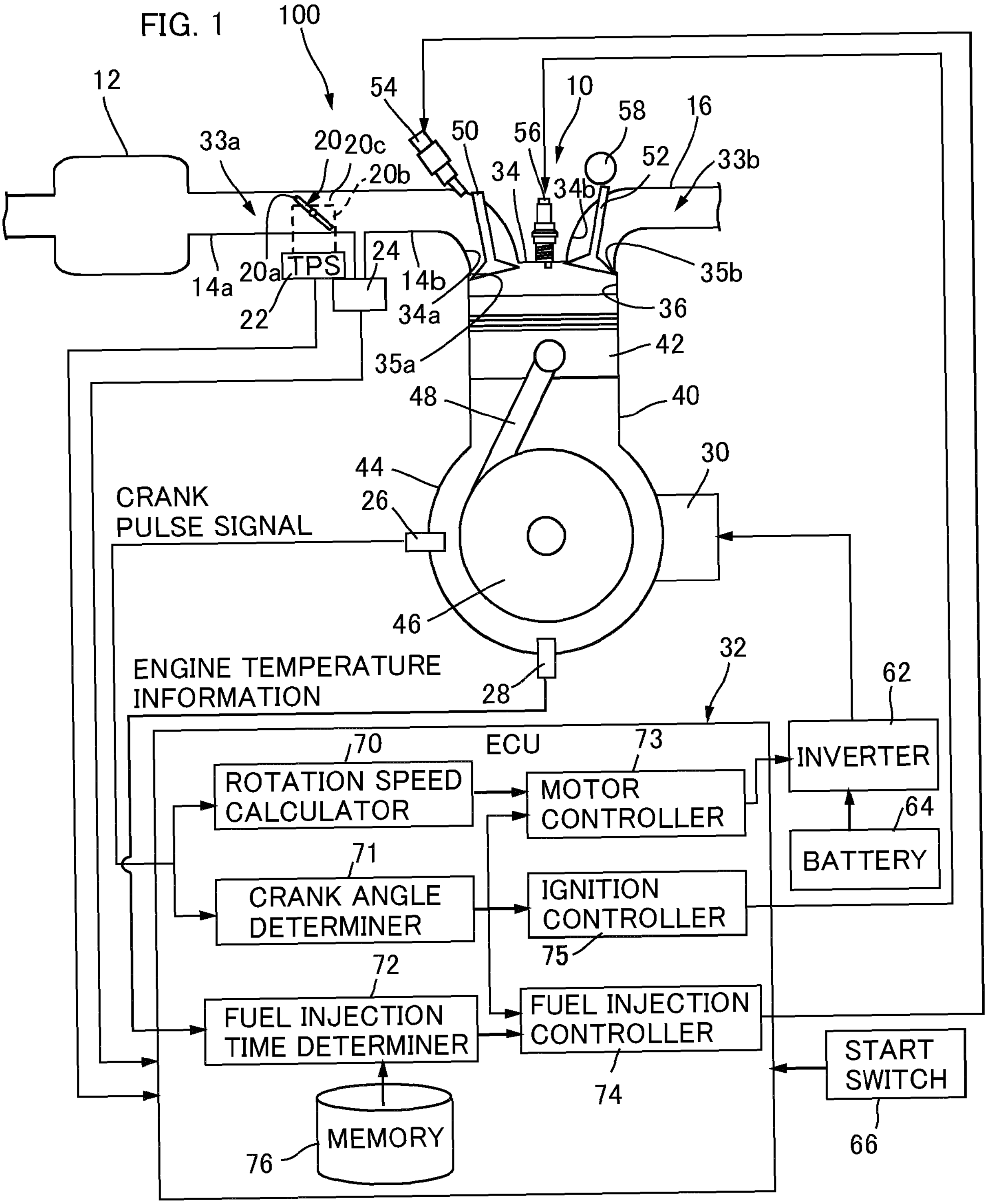
10. Procédé de commande d'un groupe moteur (100, 101) selon la revendication 9, comprenant en outre :
commander la vitesse de rotation du démarreur à aimant permanent (30) de sorte qu'une vitesse de rotation du vilebrequin (46) obtenue lorsque la température du corps du moteur à quatre temps (10) détectée par le détecteur de température de moteur (28) est une première température soit inférieure à une vitesse de rotation du vilebrequin (46) obtenue lorsque la température du corps de moteur à quatre temps (10) détectée par le détecteur de température de moteur (28) est une deuxième température supérieure à la première température.

11. Procédé de commande d'un groupe moteur (100, 101) selon la revendication 9 ou 10, comprenant en outre :
déterminer une vitesse de rotation du vilebrequin (46) conformément à un temps d'injection de carburant déterminé sur la base de la température du corps de moteur à quatre temps (10) détectée par le détecteur de température de moteur (28).

12. Procédé de commande d'un groupe moteur (100, 101) selon l'une quelconque des revendications 9 à 11, comprenant en outre : amener le dispositif d'injection de carburant (54) à injecter du carburant jusqu'à ce que le temps d'injection de carburant dépasse un temps prédéterminé pendant lequel le carburant nécessaire au démarrage du moteur peut être fourni fourni.

13. Procédé de commande d'un groupe moteur (100, 101) selon l'une quelconque des revendications 9 à 12, comprenant en outre :
commander la vitesse de rotation du moteur de sorte que, à mesure que la température du corps de moteur à quatre temps (10) détectée par le détecteur de température de moteur (28) diminue, la vitesse de rotation du vilebrequin (46), pendant le temps d'injection de carburant, diminue.

FIG. 1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34a
36
42
35a
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48
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30
CRANK
PULSE SIGNAL
26
46
ENGINE TEMPERATURE
INFORMATION
28
32
62
70
ECU
73
ROTATION SPEED
CALCULATOR
MOTOR
CONTROLLER
INVERTER
64
BATTERY
71
CRANK ANGLE
DETERMINER
IGNITION
CONTROLLER
75
72
FUEL INJECTION
TIME DETERMINER
FUEL INJECTION
CONTROLLER
74
START
SWITCH
66
MEMORY
76

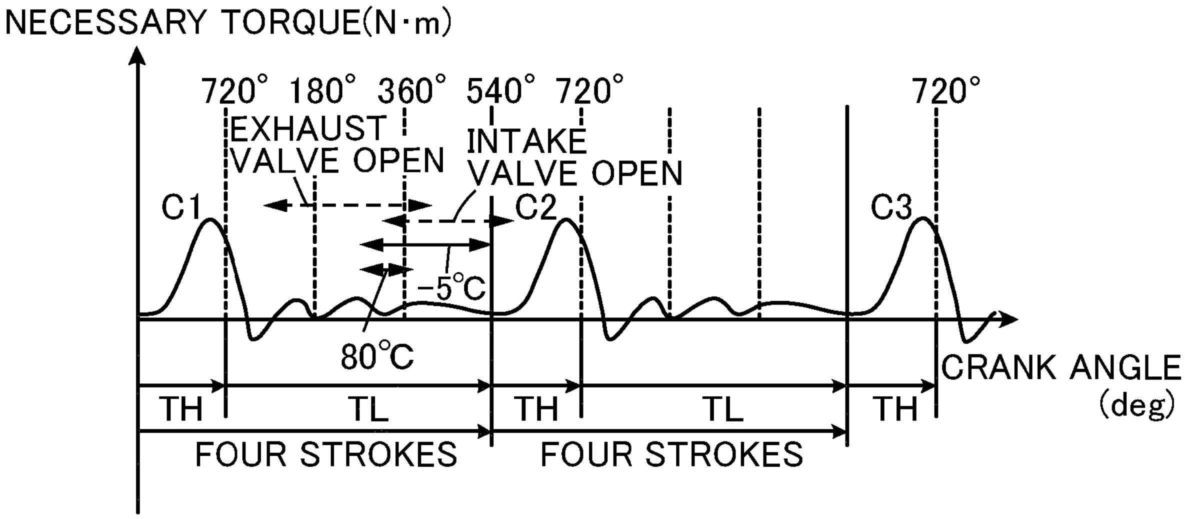

NECESSARY TORQUE(N·m)
720° 180° 360° 540° 720°
720°
EXHAUST
VALVE OPEN
INTAKE
VALVE OPEN
C1
C2
C3
-5°C
80°C
CRANK ANGLE
(deg)
TH
TL
TH
TL
TH
FOUR STROKES
FOUR STROKES

FIG. 2

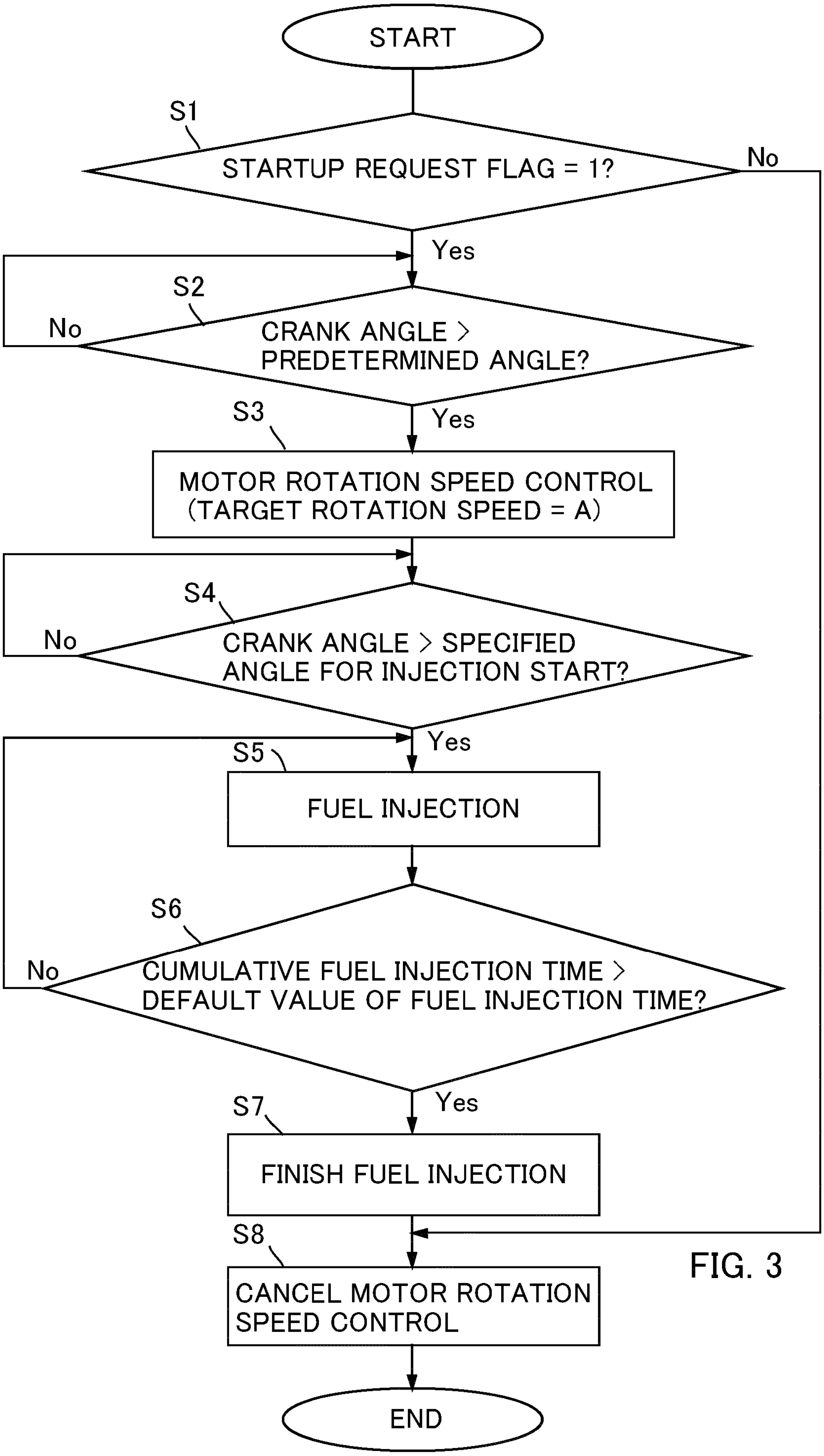

START
S1
STARTUP REQUEST FLAG = 1?
No
Yes
S2
No
CRANK ANGLE >
PREDETERMINED ANGLE?
S3
Yes
MOTOR ROTATION SPEED CONTROL
(TARGET ROTATION SPEED = A)
S4
No
CRANK ANGLE > SPECIFIED
ANGLE FOR INJECTION START?
Yes
S5
FUEL INJECTION
S6
No
CUMULATIVE FUEL INJECTION TIME >
DEFAULT VALUE OF FUEL INJECTION TIME?
S7
Yes
FINISH FUEL INJECTION
S8
CANCEL MOTOR ROTATION
SPEED CONTROL
END

FIG. 3

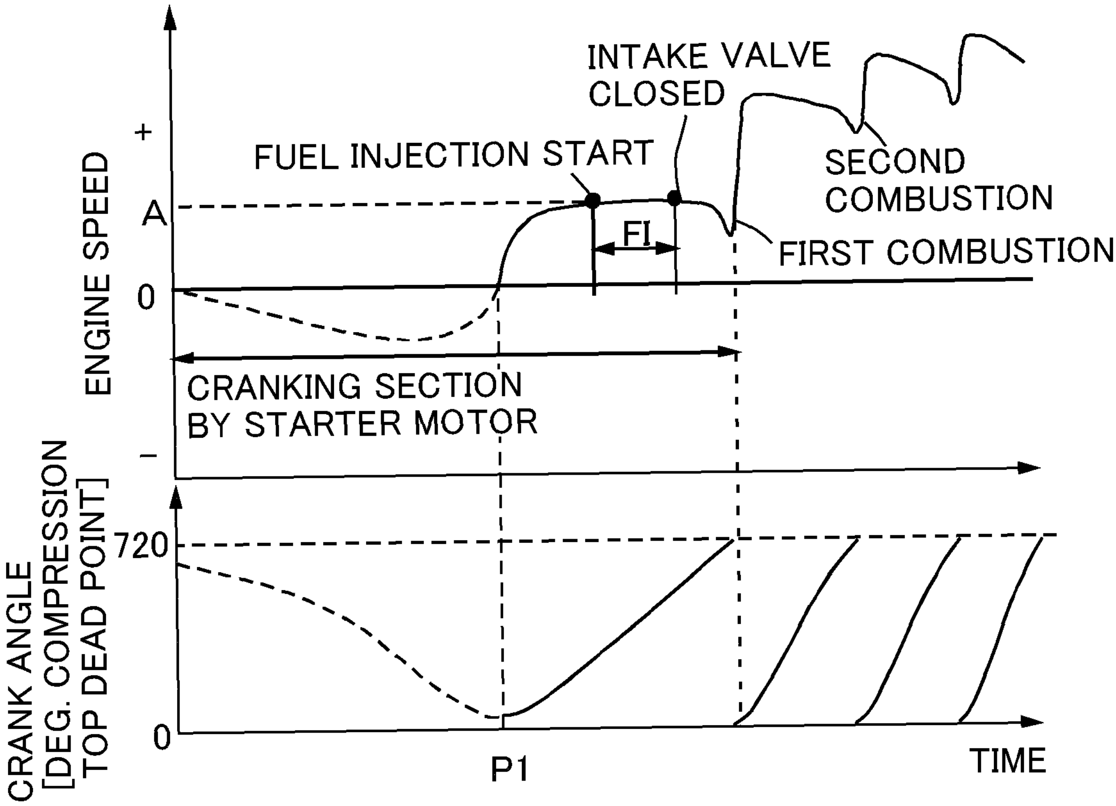

INTAKE VALVE
CLOSED
FUEL INJECTION START
+
ENGINE SPEED
A
0
FI
SECOND
COMBUSTION
FIRST COMBUSTION
CRANKING SECTION
BY STARTER MOTOR
−
CRANK ANGLE
[DEG. COMPRESSION
TOP DEAD POINT]
720
0
P1
TIME

FIG. 4

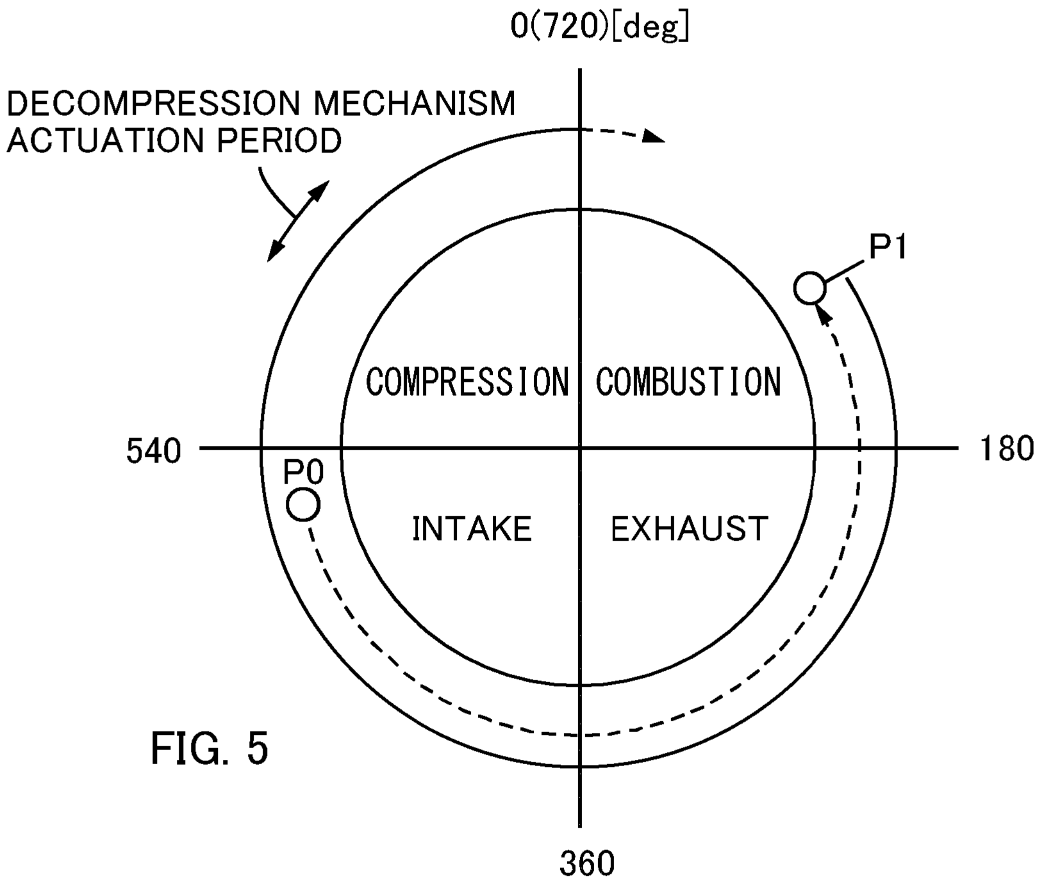

0(720)[deg]
DECOMPRESSION MECHANISM ACTUATION PERIOD
P1
COMPRESSION
COMBUSTION
540
180
P0
INTAKE
EXHAUST
360

FIG. 5

FIG. 6

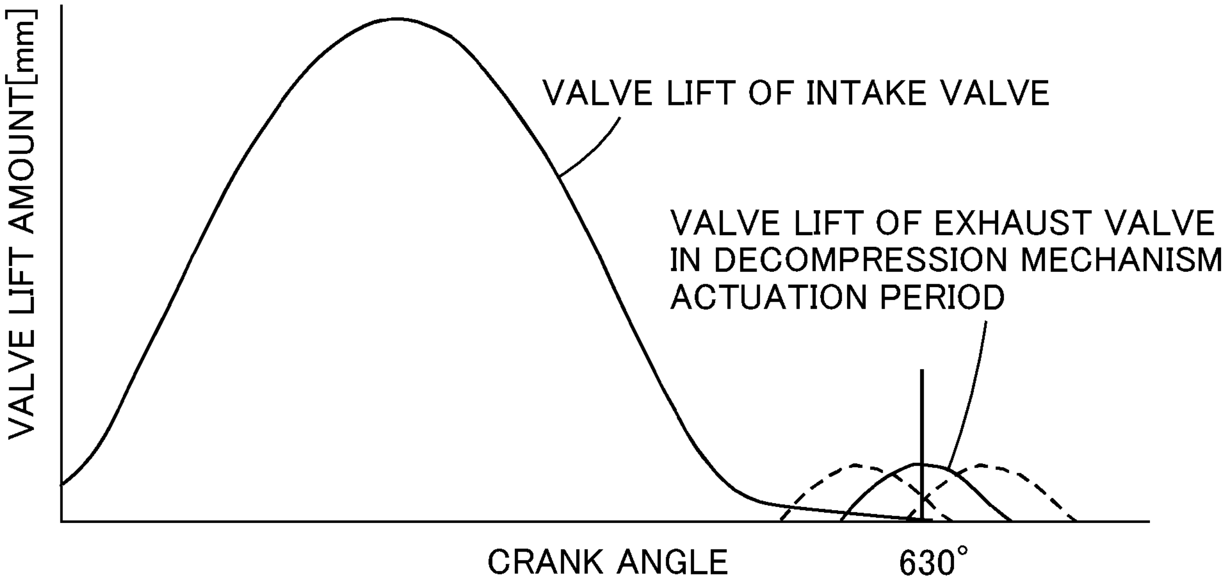

VALVE LIFT AMOUNT[mm]
VALVE LIFT OF INTAKE VALVE
VALVE LIFT OF EXHAUST VALVE IN DECOMPRESSION MECHANISM ACTUATION PERIOD
CRANK ANGLE
630°

FIG. 7

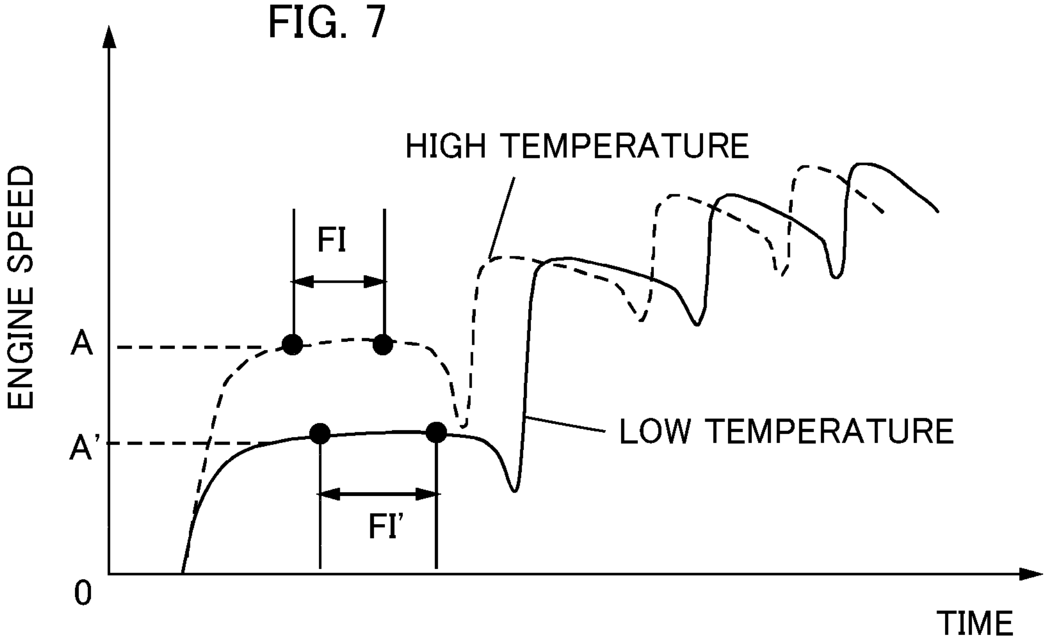

ENGINE SPEED
HIGH TEMPERATURE
FI
A
A'
FI'
LOW TEMPERATURE
0
TIME

FIG. 8A

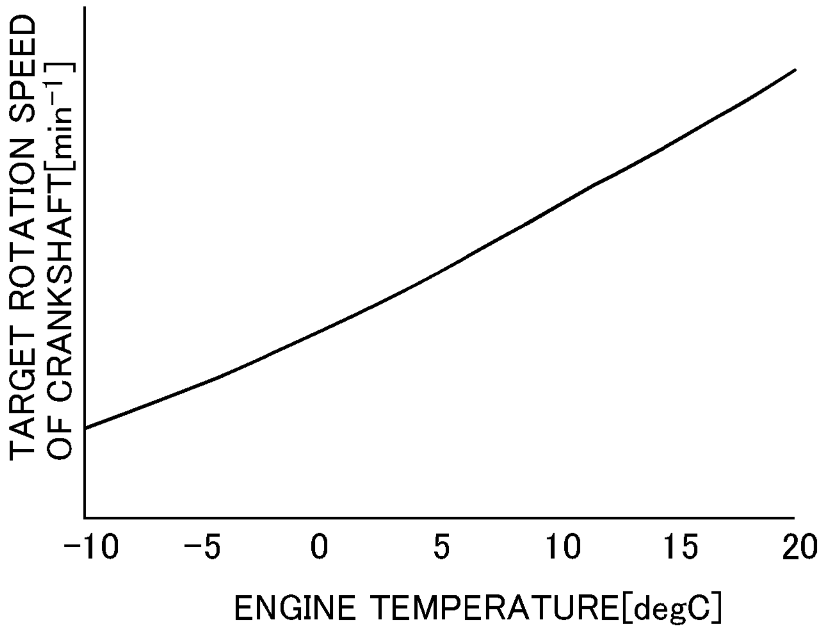
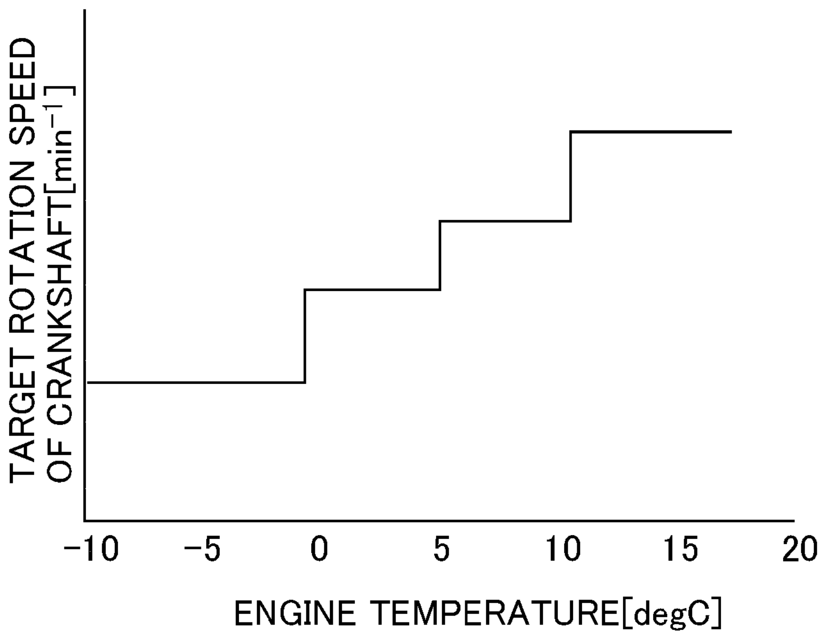

TARGET ROTATION SPEED
OF CRANKSHAFT[min^{-1}]
−10
−5
0
5
10
15
20
ENGINE TEMPERATURE[degC]

FIG. 8B


TARGET ROTATION SPEED
OF CRANKSHAFT[min^{-1}]
−10
−5
0
5
10
15
20
ENGINE TEMPERATURE[degC]

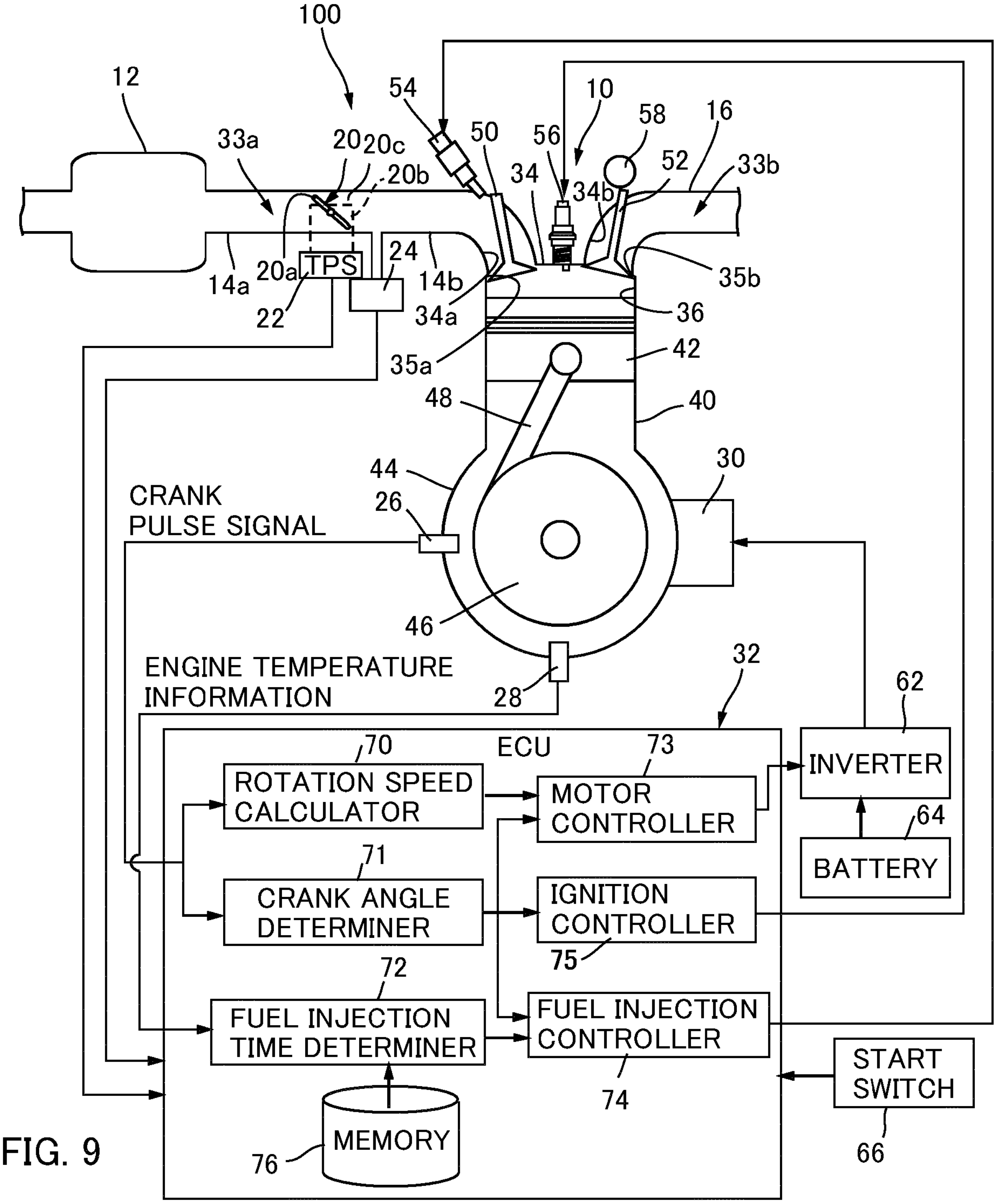
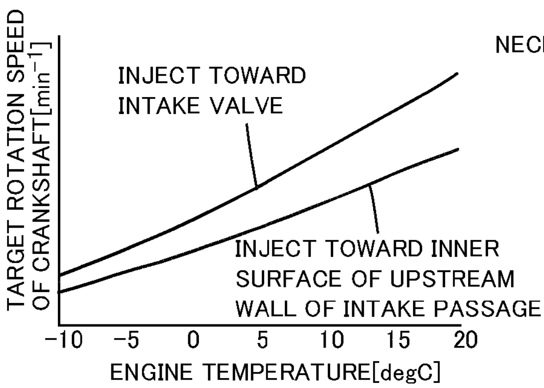
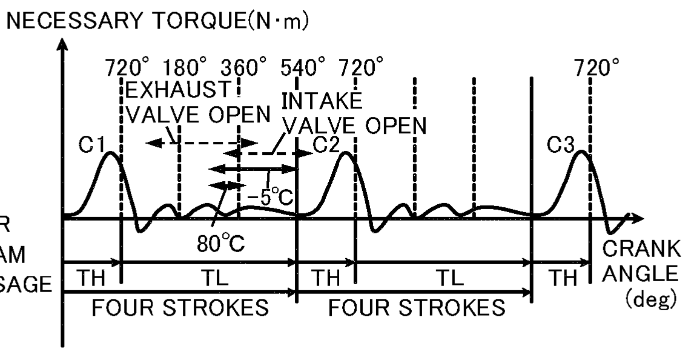

100
12
33a
20
20c
20b
54
50
56
10
58
16
52
33b
34
34b
20a
TPS
22
24
14a
14b
34a
35a
35b
36
42
48
40
44
26
30
CRANK
PULSE SIGNAL
46
ENGINE TEMPERATURE
INFORMATION
28
32
62
ECU
70
ROTATION SPEED
CALCULATOR
73
MOTOR
CONTROLLER
INVERTER
64
BATTERY
71
CRANK ANGLE
DETERMINER
IGNITION
CONTROLLER
75
72
FUEL INJECTION
TIME DETERMINER
FUEL INJECTION
CONTROLLER
74
START
SWITCH
66
MEMORY
76

FIG. 9


TARGET ROTATION SPEED OF CRANKSHAFT[min⁻¹]
INJECT TOWARD
INTAKE VALVE
INJECT TOWARD INNER
SURFACE OF UPSTREAM
WALL OF INTAKE PASSAGE
−10
−5
0
5
10
15
20
ENGINE TEMPERATURE[degC]


NECESSARY TORQUE(N·m)
720° 180° 360° 540° 720°
720°
EXHAUST
VALVE OPEN
INTAKE
VALVE OPEN
C1
C2
C3
−5°C
80°C
CRANK
ANGLE
(deg)
TH
TL
TH
TL
TH
FOUR STROKES
FOUR STROKES

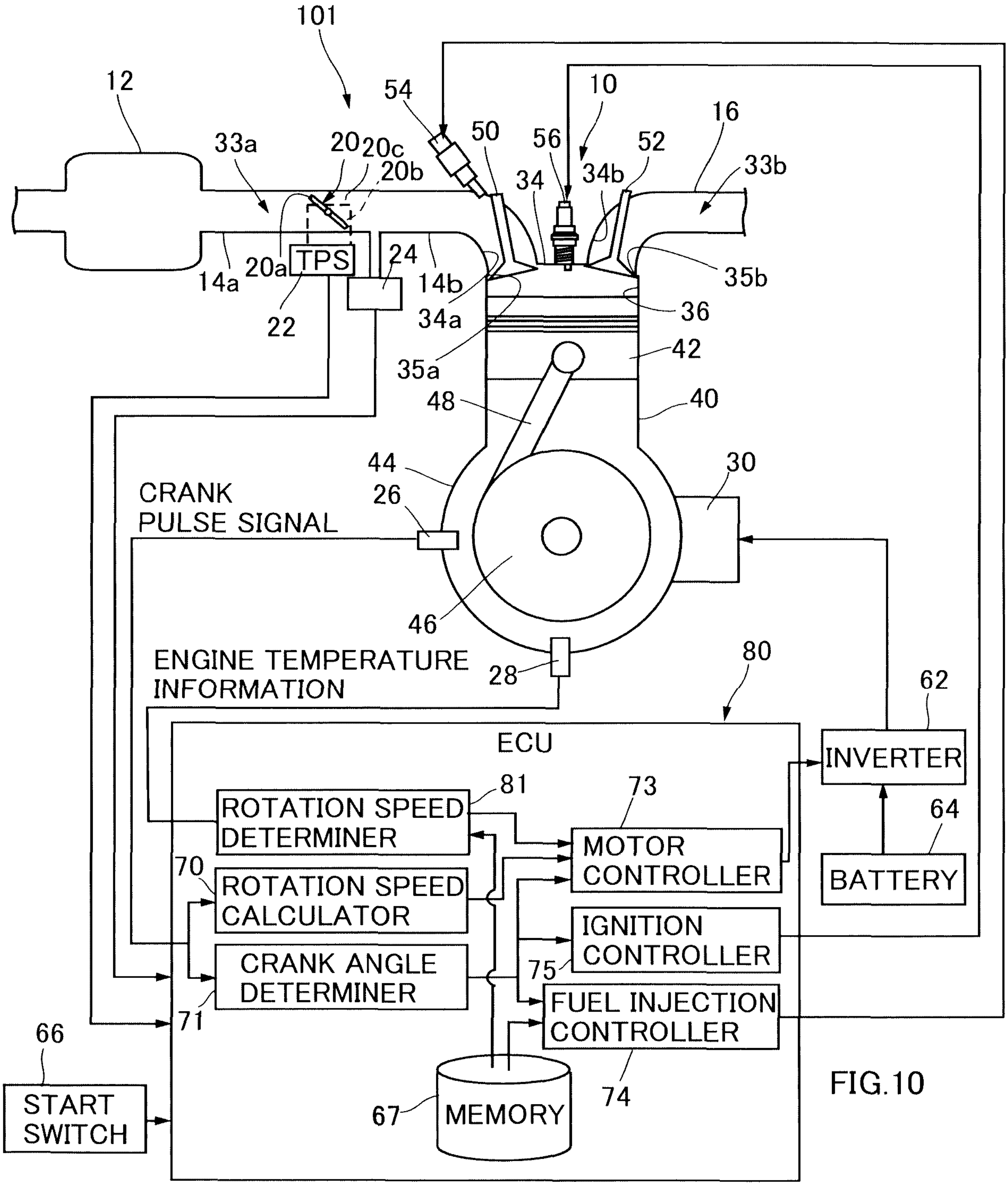
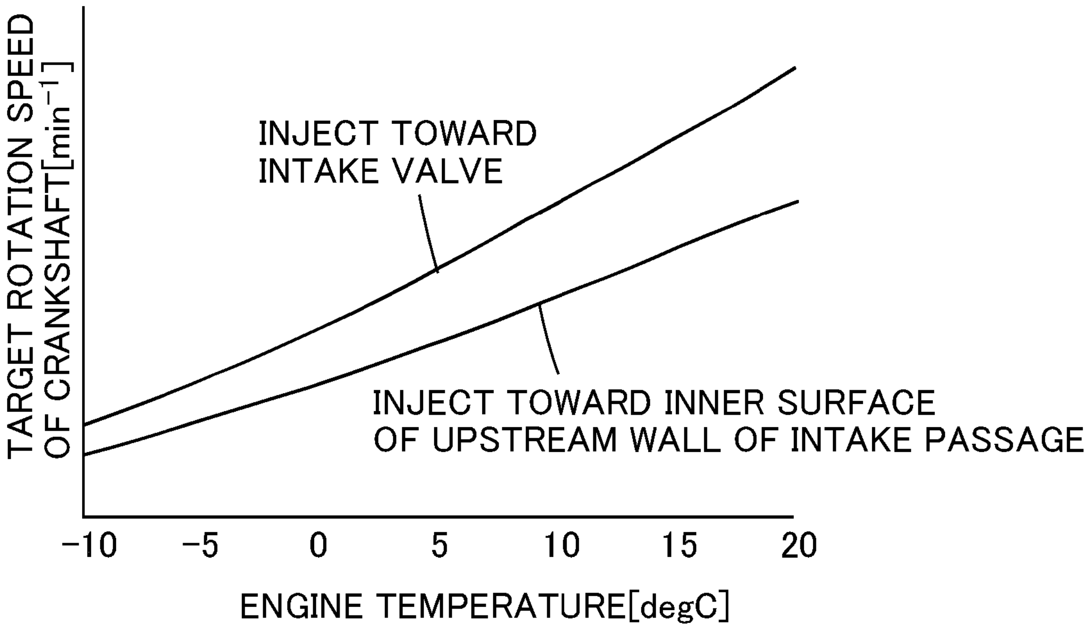

101
12
33a
20
20c
20b
54
50
56
10
34
34b
52
16
33b
14a
20a
TPS
24
14b
35b
22
34a
36
35a
42
48
40
44
30
CRANK
PULSE SIGNAL
26
46
ENGINE TEMPERATURE
INFORMATION
28
80
62
ECU
INVERTER
81
73
64
ROTATION SPEED
DETERMINER
MOTOR
CONTROLLER
BATTERY
70
ROTATION SPEED
CALCULATOR
IGNITION
CONTROLLER
CRANK ANGLE
DETERMINER
75
FUEL INJECTION
CONTROLLER
71
66
74
START
SWITCH
67
MEMORY

FIG.10

FIG. 11


TARGET ROTATION SPEED
OF CRANKSHAFT[min⁻¹]
INJECT TOWARD
INTAKE VALVE
INJECT TOWARD INNER SURFACE
OF UPSTREAM WALL OF INTAKE PASSAGE
−10
−5
0
5
10
15
20
ENGINE TEMPERATURE[degC]

REFERENCES CITED IN THE DESCRIPTION

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- JP 2003343404 A **[0003] [0010]**
- WO 2015093576 A **[0006] [0010]**
- US 20070079782 A1 **[0010]**