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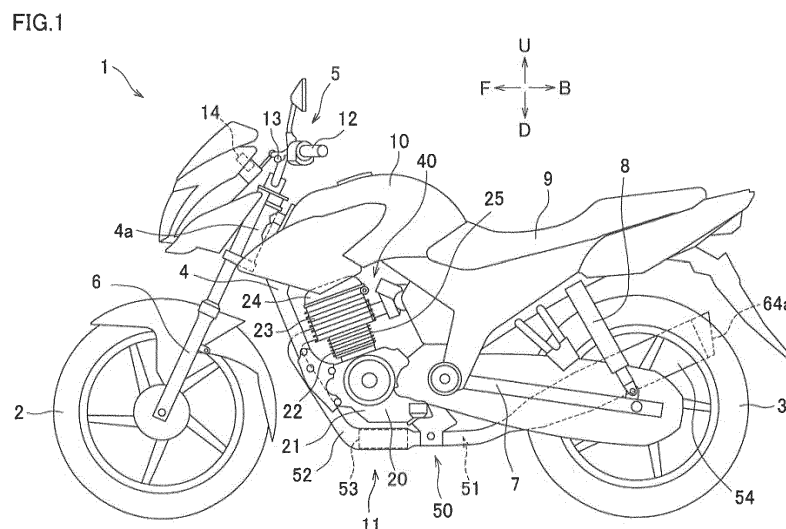
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(54) **AIR-COOLED ENGINE UNIT**

(57) An air-cooled engine unit is provided, in which deterioration of a catalyst is minimized even when the catalyst is provided close to an engine main body. An air-cooled engine unit (11) has a compression ratio of 10 or higher, and includes a close-to-combustion-chamber catalyst (53) provided in an exhaust passage member

(51). A path length of a first portion of the exhaust passage member (51), the first portion being from an exhaust port to the catalyst (53), is shorter than a path length of a second portion of the exhaust passage member (51), the second portion being from the catalyst (53) to an atmosphere discharge port (64a).



Description

Technical Field

5 **[0001]** The present invention relates to an air-cooled engine unit.

Background Art

10 **[0002]** In air-cooled engine units such as an engine unit described in Patent Literature 1, the temperature of an engine main body tends to be higher than that in water-cooled engine units. Because of this, knocking is more likely to occur in the air-cooled engine units than in the water-cooled engine units. In order to prevent knocking, the air-cooled engine units have been designed to have a somewhat lower compression ratio than the water-cooled engine units.

Citation List

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Patent Literature

[0003] Patent Literature 1: Japanese Unexamined Patent Publication No. H10-067372

20 Summary of Invention

Technical Problem

25 **[0004]** Such an air-cooled engine unit includes a catalyst configured to purify exhaust gas. The air-cooled engine unit is required to reduce the length of time it takes for the catalyst to transition from a deactivated state to an activated state. In the following description, the length of time it takes for the catalyst to transition from the deactivated state to the activated state is referred to as a "time needed for activation of the catalyst". One example approach to the reduction of the time needed for activation of the catalyst is to provide the catalyst close to the engine main body of the engine unit. Now, it should be noted that the air-cooled engine unit has a low compression ratio. For this reason, if the catalyst is provided close to the engine main body, the catalyst may overheat, which may lead to deterioration of the catalyst.

30 **[0005]** An object of the present invention is to provide an air-cooled engine unit in which deterioration of a catalyst is minimized even when the catalyst is provided close to an engine main body.

Solution to Problem and Advantageous Effects of Invention

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[0006] According to an embodiment of the present teaching, an engine unit includes: an engine main body having a compression ratio of 10 or higher and forming at least one combustion chamber; a heat dissipater configured to dissipate heat generated in the engine main body from a surface of the engine main body; an exhaust passage member connecting an exhaust port provided through the combustion chamber with an atmosphere discharge port through which exhaust gas is discharged to the atmosphere, the exhaust gas flowing inside the exhaust passage member from the exhaust port to the atmosphere discharge port; and a close-to-combustion-chamber catalyst provided in the exhaust passage member. A path length of a first portion of the exhaust passage member is shorter than a path length of a second portion of the exhaust passage member, the first portion of the exhaust passage member being from the exhaust port to an upstream end of the close-to-combustion-chamber catalyst, the second portion of the exhaust passage member being from a downstream end of the close-to-combustion-chamber catalyst to the atmosphere discharge port.

40 **[0007]** The air-cooled engine unit includes: the engine main body; the heat dissipater; the exhaust passage member; and the close-to-combustion-chamber catalyst. The engine main body forms the at least one combustion chamber. The heat dissipater is configured to dissipate heat generated in the engine main body from the surface of the engine main body. The exhaust passage member connects the exhaust port provided through the combustion chamber with the atmosphere discharge port through which exhaust gas is discharged to the atmosphere. The exhaust gas flows in the exhaust passage member from the exhaust port to the atmosphere discharge port. The close-to-combustion-chamber catalyst is provided in the exhaust passage member. The path length of the first portion of the exhaust passage member is shorter than the path length of the second portion of the exhaust passage member, the first portion of the exhaust passage member being from the exhaust port to the upstream end of the close-to-combustion-chamber catalyst, the second portion of the exhaust passage member being from the downstream end of the close-to-combustion-chamber catalyst to the atmosphere discharge port. That is, the close-to-combustion-chamber catalyst is provided close to the engine main body. This enables reduction in the time needed for activation of the catalyst.

55 **[0008]** Generally, in air-cooled engines, the temperature of the engine main body tends to be higher than in water-

cooled engines. In this regard, however, the engine main body of the air-cooled engine unit of the present teaching has a compression ratio of 10 or higher, which is higher than those in known air-cooled engine units. Due to the high compression ratio, the exhaust gas discharged from the combustion chamber has a lower temperature. Because of this, even though the close-to-combustion-chamber catalyst is provided close to the engine main body, the temperature of the exhaust gas flowing into the close-to-combustion-chamber catalyst is lower. Thus, the deterioration of the close-to-combustion-chamber catalyst due to overheating can be minimized even though the close-to-combustion-chamber catalyst is provided close to the engine main body.

[0009] It is preferable that the air-cooled engine unit of the present teaching is arranged to include a controller configured to control operation of the air-cooled engine unit, wherein the controller includes: an idle-stop controlling unit configured to automatically stop the air-cooled engine unit from running when an idle-stop condition is satisfied during running of the air-cooled engine unit; and a restart controlling unit configured to restart the air-cooled engine unit to get the engine unit to run when a restart condition is satisfied in a situation in which the air-cooled engine unit has been stopped from running by the idle-stop controlling unit.

[0010] The controller includes the idle-stop controlling unit and the restart controlling unit. The idle-stop controlling unit is configured to automatically stop the air-cooled engine unit from running when the idle-stop condition is satisfied during running of the air-cooled engine unit. The above-described control of stopping the engine unit may be referred to as an "idle-stop control". The restart controlling unit is configured to restart the air-cooled engine unit to get the engine unit to run when the restart condition is satisfied in the situation in which the air-cooled engine unit has been stopped from running by the idle-stop controlling unit. That is, when the idle-stop condition is satisfied during an idle time in which the engine unit is idling, the air-cooled engine unit is stopped from running automatically. When the restart condition is satisfied thereafter, the air-cooled engine unit is restarted.

[0011] During the idle time, exhaust gas discharged from the combustion chamber has a lower temperature. The air-cooled engine unit has the high compression ratio. Because of this, exhaust gas discharged from the combustion chamber of this engine unit during the idle time has a further lower temperature. In this air-cooled engine unit, however, the idle-stop control is performed, and this prevents a long-time duration of the idle state. This also prevents the drop of the temperature of the catalyst below its activation temperature. As a result, improvement in exhaust gas purification performance is achievable.

[0012] It is preferable that the air-cooled engine unit of the present teaching is arranged to include: a knocking sensor configured to detect knocking occurring in the engine main body; an ignition device configured to ignite fuel in the combustion chamber; and a controller configured to control an ignition timing of the ignition device based on a signal from the knocking sensor.

[0013] In the above arrangement, the air-cooled engine unit includes the knocking sensor, the ignition device, and the controller. The knocking sensor is configured to detect knocking occurring in the engine main body. The ignition device is configured to ignite the fuel in the combustion chamber. The controller is configured to control the ignition timing of the ignition device configured to ignite the fuel in the combustion chamber, based on a signal from the knocking sensor. To be more specific, the controller retards the ignition timing when knocking is detected. This prevents occurrence of large knocking.

[0014] Knocking is more likely to occur in an engine main body having a high compression ratio. However, this air-cooled engine unit includes the knocking sensor, and the ignition timing is retarded if knocking occurs. This eliminates the necessity for extra retard of the ignition timing as a precaution against knocking. In other words, the amount of retard of the ignition timing is reducible. The reduction of the amount of retard lowers the temperature of the exhaust gas discharged from the combustion chamber. Thus, it is possible to lower the temperature of the exhaust gas while minimizing the amount of retard of the ignition timing. As a consequence, the deterioration of the close-to-combustion-chamber catalyst due to overheating can be further minimized, with sufficient torque.

[0015] It is preferable that the air-cooled engine unit of the present teaching is arranged to include: an oxygen sensor provided to the exhaust passage member, the oxygen sensor being provided upstream of the close-to-combustion-chamber catalyst in a direction of flow of the exhaust gas, and being configured to detect oxygen concentration in the exhaust gas in the exhaust passage member; a fuel supplier configured to supply fuel into the combustion chamber; and a controller configured to control a fuel supply amount of the fuel supplier based on a signal from the oxygen sensor.

[0016] In the above arrangement, the air-cooled engine unit includes the oxygen sensor, the fuel supplier, and the controller. The oxygen sensor is provided to the exhaust passage member and provided upstream of the close-to-combustion-chamber catalyst in the direction of flow of the exhaust gas. The oxygen sensor is configured to detect oxygen concentration in the exhaust gas in the exhaust passage member. The fuel supplier is configured to supply fuel into the combustion chamber. The controller is configured to control the fuel supply amount of the fuel supplier based on a signal from the oxygen sensor.

[0017] The high compression ratio of the engine main body results in low temperature of the exhaust gas. The low temperature of the exhaust gas lowers the temperature of the oxygen sensor provided to the exhaust passage member. If the temperature of the oxygen sensor drops too low, the oxygen sensor is deactivated. This reduces the detection

accuracy of the oxygen sensor. In this air-cooled engine unit, however, the oxygen sensor is provided upstream of the close-to-combustion-chamber catalyst provided close to the engine main body. That is, the oxygen sensor is provided even closer to the engine main body than the close-to-combustion-chamber catalyst. This arrangement enables the exhaust gas in contact with the oxygen sensor to have a higher temperature. That is, this arrangement makes the temperature drop of the oxygen sensor smaller. Accordingly, the oxygen sensor is kept activated. As a consequence, the precision of the control of the fuel supply amount is maintained.

[0018] It is preferable that the air-cooled engine unit of the present teaching is arranged to include: an intake passage member connecting an intake port provided through the combustion chamber with an atmosphere suction port through which air is taken in from the atmosphere, the air flowing inside the intake passage member from the atmosphere suction port to the intake port; an ignition device configured to ignite fuel in the combustion chamber; a fuel supplier configured to supply fuel into the combustion chamber; a close-to-combustion-chamber throttle valve provided in the intake passage member, the close-to-combustion-chamber throttle valve being positioned so that a path length of a first portion of the intake passage member is longer than a path length of a second portion of the intake passage member, the first portion of the intake passage member being from the atmosphere suction port to the close-to-combustion-chamber throttle valve, the second portion of the intake passage member being from the close-to-combustion-chamber throttle valve to the intake port; a close-to-combustion-chamber throttle position sensor configured to detect an opening degree of the close-to-combustion-chamber throttle valve; an engine rotation speed sensor configured to detect engine rotation speed; and a controller configured to control a fuel supply amount of the fuel supplier and to control an ignition timing of the ignition device based on a signal from the close-to-combustion-chamber throttle position sensor and based on a signal from the engine rotation speed sensor.

[0019] In the above arrangement, the air-cooled engine unit includes: the intake passage member; the ignition device; the fuel supplier; the close-to-combustion-chamber throttle valve; the close-to-combustion-chamber throttle position sensor; the engine rotation speed sensor; and the controller. The intake passage member connects the intake port provided through the combustion chamber with the atmosphere suction port through which air is taken in from the atmosphere. The air flows in the intake passage member from the atmosphere suction port to the intake port. The ignition device is configured to ignite the fuel in the combustion chamber. The fuel supplier is configured to supply fuel into the combustion chamber. The close-to-combustion-chamber throttle valve is provided in the intake passage member. The close-to-combustion-chamber throttle position sensor is configured to detect the opening degree of the close-to-combustion-chamber throttle valve. The engine rotation speed sensor is configured to detect the engine rotation speed. The controller is configured to control the fuel supply amount of the fuel supplier and to control the ignition timing of the ignition device based on a signal from the close-to-combustion-chamber throttle position sensor and based on a signal from the engine rotation speed sensor.

[0020] The path length of the second portion of the intake passage member, the second portion being from the close-to-combustion-chamber throttle valve to the intake port, is shorter than the path length of the first portion of the intake passage member, the first portion being from the atmosphere suction port to the close-to-combustion-chamber throttle valve. That is, the close-to-combustion-chamber throttle valve is provided close to the combustion chamber. Due to this, there is less delay in the change of the amount of air taken into the combustion chamber, in relation to the change in the opening degree of the close-to-combustion-chamber throttle valve.

[0021] The controller is configured to control the fuel supply amount and the ignition timing based on a signal from the close-to-combustion-chamber throttle position sensor. Because of this, there is less delay in the change of the fuel supply amount and in the change of the ignition timing, in relation to the change in the opening degree of the close-to-combustion-chamber throttle valve. As described above, there is less delay in the change of the amount of air taken into the combustion chamber, in relation to the change in the opening degree of the close-to-combustion-chamber throttle valve. Due to this, when the opening degree of the close-to-combustion-chamber throttle valve changes, there is a small time lag between: the change of each of the fuel supply amounts and the ignition timing in response to the change in the valve opening degree; and the change of the amount of air taken into the combustion chamber in response to the change in the valve opening degree. This enables improvement in the precision of the control of the fuel supply amount and the ignition timing.

[0022] The improvement in the precision of the control of the ignition timing also provides the following advantageous effect. Specifically, it is possible to reduce the extra retard of the ignition timing as a precaution against knocking even if a knocking sensor is not provided. Due to the reduction of the extra retard, the temperature of the exhaust gas is lowered while the amount of retard of the ignition timing is minimized. As a consequence, the deterioration of the close-to-combustion-chamber catalyst due to overheating can be minimized, with sufficient torque.

[0023] It is preferable that: the air-cooled engine unit of the present teaching is arranged to include an intake passage member connecting an intake port provided through the combustion chamber with an atmosphere suction port through which air is taken in from the atmosphere, the air flowing inside the intake passage member from the atmosphere suction port to the intake port; but the air-cooled engine unit does not include: an intake pressure sensor provided for the intake passage member and configured to detect internal pressure in the intake passage member; and an intake temperature sensor provided for the intake passage member and configured to detect temperature in the intake passage member.

[0024] In the above arrangement, the air-cooled engine unit does not include the intake pressure sensor configured to detect the internal pressure in the intake passage member. Furthermore, the air-cooled engine unit does not include the intake temperature sensor configured to detect the temperature in the intake passage member. Because of these, intake pressure and intake temperature are not used to control the fuel supply amount and the ignition timing. This makes the control of the fuel supply amount and the control of the ignition timing simpler.

Brief Description of the Drawings

[0025]

[FIG. 1] FIG. 1 is a left side view of a motorcycle in which an air-cooled engine unit of an embodiment is used.

[FIG. 2] FIG. 2 is a schematic diagram of the air-cooled engine unit.

[FIG. 3] FIG. 3 is a schematic sectional view of a muffler.

[FIG. 4] FIG. 4 is a control block diagram of the air-cooled engine unit.

[FIG. 5] FIG. 5 is a diagram specifically illustrating a part of the control block of the air-cooled engine unit.

[FIG. 6] FIG. 6 is a map for an intake air amount, associated with throttle opening degree and engine rotation speed.

[FIG. 7] FIG. 7 is a graph illustrating an example of the relationship between the throttle opening degree, the engine rotation speed, and a basic fuel supply amount.

[FIG. 8] FIG. 8 is a diagram illustrating the relationship between the throttle opening degree, the engine rotation speed, and an oxygen feedback control area.

[FIG. 9] FIG. 9 is a diagram illustrating the relationship between the throttle opening degree, the engine rotation speed, and an oxygen feedback learning area.

[FIG. 10] FIG. 10 is a graph illustrating an example of the relationship between the throttle opening degree, the engine rotation speed, and a basic ignition timing.

[FIG. 11] FIG. 11 is a diagram illustrating the relationship between the throttle opening degree, the engine rotation speed, and a knocking control area.

Description of Embodiments

[0026] The following describes an embodiment of the present teaching. This embodiment deals with an example of a motorcycle in which the air-cooled engine unit of the present teaching is used. In the following description, a front-back direction refers to a vehicle's front-back direction as seen from a rider seated on a seat 9 of a motorcycle 1. The seat 9 is described later. A left-right direction refers to a vehicle's left-right direction as seen from the rider seated on the seat 9. The vehicle's left-right direction is the same as a vehicle's width direction. Arrows F and B in FIG. 1 respectively indicate a forward direction and a backward direction. Arrows U and D respectively indicate an upward direction and a downward direction.

[Overall Structure of Motorcycle]

[0027] As shown in FIG. 1, the motorcycle 1 of this embodiment includes a front wheel 2, a rear wheel 3, and a vehicle body frame 4. The vehicle body frame 4 has, at its front portion, a head pipe 4a. A steering shaft (not illustrated) is inserted into the head pipe 4a in a rotatable manner. An upper end portion of the steering shaft is coupled to a handle unit 5. Upper end portions of a pair of front forks 6 are secured to the handle unit 5. Lower end portions of the front forks 6 support the front wheel 2.

[0028] The handle unit 5 is provided with a right grip (not illustrated) and a left grip 12. The right grip is a throttle grip configured to adjust engine power. As the rider rotates the throttle grip towards the rider with the hand gripping the throttle grip, the engine power increases. Specifically, the throttle opening degree increases. As the rider rotates the throttle grip in the opposite direction, the engine power decreases. Specifically, the throttle opening degree decreases. Moreover, a brake lever 13 is provided in front of the left grip 12. In addition, a display device 14 is provided in front of the handle unit 5. Although not illustrated, the display device 14 is configured to display thereon vehicle speed, engine rotation speed, and the like. Furthermore, the display device 14 is provided with indicators (indicator lamps).

[0029] A pair of swingarms 7 are supported by the vehicle body frame 4 in a swingable manner. Rear end portions of the swingarms 7 support the rear wheel 3. Rear suspensions 8 are respectively attached to the swingarms 7. One end portion of each suspension 8 is connected to a portion of the corresponding swingarm 7, the portion being rearward of the swingarm pivot. The other end portion of each rear suspension 8 is attached to the vehicle body frame 4.

[0030] The seat 9 and a fuel tank 10 are supported by an upper portion of the vehicle body frame 4. The fuel tank 10 is in front of the seat 9. Furthermore, an air-cooled engine unit 11 is mounted on the vehicle body frame 4. The air-cooled engine unit 11 is provided below the fuel tank 10. Furthermore, a battery (not illustrated) is mounted on the vehicle body

frame 4. The battery is configured to supply electrical power to electronic equipment such as various types of sensors.

[Structure of Air-Cooled Engine Unit]

[0031] The air-cooled engine unit 11 is a natural air-cooled engine. The air-cooled engine unit 11 is a four-stroke single-cylinder engine. The four-stroke engine is structured so that an engine cycle constituted by the intake stroke, the compression stroke, the combustion (expansion) stroke, and the exhaust stroke is repeated. The air-cooled engine unit 11 includes: an engine main body 20; an intake unit 40; and an exhaust unit 50.

[0032] The engine main body 20 includes a crankcase 21, a cylinder body 22, a cylinder head 23, and a head cover 24. The cylinder body 22 is attached to an upper end portion of the crankcase 21. The cylinder head 23 is attached to an upper end portion of the cylinder body 22. The head cover 24 is attached to an upper end portion of the cylinder head 23.

[0033] A fin portion 25 is provided on at least a part of a surface of the engine main body 20. The fin portion 25 ranges over the cylinder body 22 and the cylinder head 23. The fin portion 25 consists of a plurality of fins. Each of the fins projects from the surface of the engine main body 20. The fin portion 25 is provided throughout the substantially entire circumferences of the cylinder body 22 and the cylinder head 23. The fin portion 25 is configured to dissipate heat generated in the engine main body 20. The fin portion 25 is equivalent to a heat dissipater in the present teaching.

[0034] FIG. 2 is a schematic diagram illustrating the air-cooled engine unit 11. As shown in FIG. 2, the crankcase 21 accommodates therein a crankshaft 26, a starter motor 27, a gearbox (not illustrated), a generator (not illustrated), and the like. The gearbox is configured to change the ratio between the rotation speed of the crankshaft 26 and the rotation speed of the rear wheel 3. Rotation of the crankshaft 26 is transmitted to the rear wheel 3 via the gearbox. The starter motor 27 rotates the crankshaft 26 at the time of engine start-up. The starter motor 27 is powered by the battery (not illustrated). The generator is configured to generate electrical power with the use of the rotation of the crankshaft 26. The battery is charged with electricity generated by the generator. Instead of the starter motor 27 and the generator, an Integrated Starter Generator (ISG) may be provided. The ISG is a device in which the starter motor and the generator are integrated.

[0035] An engine rotation speed sensor 71 and a knocking sensor 72 are provided in the crankcase 21. The engine rotation speed sensor 71 is configured to detect the rotation speed of the crankshaft 26, i.e., engine rotation speed. The engine rotation speed is the number of rotations of the crankshaft 26 per unit time. The knocking sensor 72 is configured to detect knocking occurring in the engine main body 20. Knocking is a phenomenon in which metallic pinging sounds or pinging vibrations occur due to abnormal combustion in a later-described combustion chamber 30. Normally, combustion of an air-fuel mixture is started by ignition due to spark discharge, and the flame of the burning air-fuel mixture propagates in the combustion chamber. Note that, in this description, an air-fuel mixture is the mixture of air and fuel. Knocking is caused by spontaneous ignition of unburned air-fuel mixture, to which the flame propagation does not extend, in the combustion chamber 30. The knocking sensor 72 may have any configuration as long as it is able to detect knocking.

[0036] The cylinder body 22 has a cylinder hole 22a. A piston 28 is provided in the cylinder hole 22a in a slidable manner. The piston 28 is coupled to the crankshaft 26 via a connecting rod 29. An engine temperature sensor 73 is provided to the engine main body 20. The engine temperature sensor 73 is configured to detect the temperature of the engine main body 20. Specifically, the engine temperature sensor 73 is configured to detect the temperature of the cylinder body 22.

[0037] The combustion chamber 30 (see FIG. 2) is formed by: an underside of the cylinder head 23; the cylinder hole 22a; and the piston 28. In this description, a space formed by the underside of the cylinder head 23, the cylinder hole 22a, and the piston 28 is the combustion chamber 30, irrespective of the position of the piston 28. The engine main body 20 has a compression ratio of 10 or higher. The compression ratio is a value obtained by dividing the volume of the combustion chamber 30 at the time when the piston 28 is at the bottom dead center by the volume of the combustion chamber 30 at the time when the piston 28 is at the top dead center.

[0038] A leading end portion of a spark plug 31 is in the combustion chamber 30. The spark plug 31 produces, from its leading end portion, an electrical spark. The spark discharge ignites the air-fuel mixture in the combustion chamber 30. The spark plug 31 is wired to an ignition coil 32. The ignition coil 32 stores electrical power to enable the spark discharge from the spark plug 31. The combination of the spark plug 31 and the ignition coil 32 is equivalent to an ignition device in the present teaching.

[0039] An intake port 33 and an exhaust port 34 are provided through the surface of the cylinder head 23, the surface forming the combustion chamber 30. That is, the intake port 33 and the exhaust port 34 are provided through the combustion chamber 30. The intake port 33 is opened/closed by an intake valve 35. The exhaust port 34 is opened/closed by an exhaust valve 36. The intake valve 35 and the exhaust valve 36 are actuated by a valve moving device (not illustrated) housed in the cylinder head 23. The valve moving device operates in association with the crankshaft 26.

[0040] The air-cooled engine unit 11 includes an intake passage member 41 connecting the intake port 33 with an atmosphere suction port 41c exposed to the atmosphere. Herein, the "passage member" means a wall structure or the like that is around a path and forms therein the path. The path means a space through which an object passes. Air is

taken in from the atmosphere through the atmosphere suction port 41 c. The air, taken in through the atmosphere suction port 41 c, flows inside the intake passage member 41 towards the intake port 33. A part of the intake passage member 41 is included in the engine main body 20, and the remaining part of the intake passage member 41 is included in the intake unit 40. The intake unit 40 includes an intake pipe connected to the engine main body 20. The intake unit 40 further includes an injector 42, a throttle valve 45, and a bypass valve 46. In the following description, upstream and downstream in the direction of airflow in the intake passage member 41 may be simply referred to as upstream and downstream, respectively.

[0041] The air-cooled engine unit 11 includes an exhaust passage member 51 connecting the exhaust port 34 with an atmosphere discharge port 64a exposed to the atmosphere. Combustion gas generated in the combustion chamber 30 is discharged to the exhaust passage member 51 via the exhaust port 34. The combustion gas discharged from the combustion chamber 30 is referred to as exhaust gas. Exhaust gas flows inside the exhaust passage member 51 towards the atmosphere discharge port 64a. The exhaust gas is discharged to the atmosphere through the atmosphere discharge port 64a. A part of the exhaust passage member 51 is included in the engine main body 20, and the remaining part of the exhaust passage member 51 is included in the exhaust unit 50. The exhaust unit 50 includes an exhaust pipe 52 (see FIG. 1) connected to the engine main body 20. The exhaust unit 50 further includes a catalyst 53 and a muffler 54. The muffler 54 is a device configured to reduce the amount of noise made by the exhaust gas. In the following description, upstream and downstream in the direction of flow of the exhaust gas in the exhaust passage member 51 may be simply referred to as upstream and downstream, respectively.

[0042] The injector 42 is provided to the intake passage member 41. The injector 42 is configured to inject fuel to the air taken in through the atmosphere suction port 41 c. To be more specific, the injector 42 is configured to inject fuel to the air in the intake passage member 41. The injector 42 is equivalent to a fuel supplier in the present teaching. The injector 42 is connected to a fuel hose 43, which is connected to the fuel tank 10. A fuel pump 44 is provided in the fuel tank 10. The fuel pump 44 is configured to feed fuel from the fuel tank 10 to the fuel hose 43 under pressure.

[0043] The intake passage member 41 includes a main intake passage member 41 a and a bypass intake passage member 41 b. The throttle valve 45 is provided in the main intake passage member 41a. The throttle valve 45 is provided upstream of the injector 42. The bypass intake passage member 41b is connected to the main intake passage member 41a so as to bypass the throttle valve 45. That is, the bypass intake passage member 41 b establishes communication between an upstream portion and a downstream portion of the main intake passage member 41 a, the upstream and downstream portions being respectively upstream and downstream of the throttle valve 45. The throttle valve 45 is equivalent to a "close-to-combustion-chamber throttle valve" in the present teaching.

[0044] The path formed inside the intake passage member 41 is referred to as an intake path. A path length of a freely-selected portion of the intake passage member 41 means the length of the path formed in the freely-selected portion. As shown in FIG. 2, a path length of a first portion of the intake passage member 41, the first portion being from the atmosphere suction port 41c to the throttle valve 45, is called a path length D1. A path length of a second portion of the intake passage member 41, the second portion being from the throttle valve 45 to the intake port 33, is called a path length D2. The path length D2 is shorter than the path length D1. That is, the throttle valve 45 is close to the combustion chamber 30. The volume of the first portion of the intake passage member 41, the first portion being from the atmosphere suction port 41 c to the throttle valve 45, is called a volume V1. The volume of the second portion of the intake passage member 41, the second portion being from the throttle valve 45 to the intake port 33, is called a volume V2. The volume V1 is larger than the volume V2.

[0045] The throttle valve 45 is connected to the throttle grip (not illustrated) by a throttle wire. The opening degree of the throttle valve 45 is changed as the rider rotates the throttle grip. The air-cooled engine unit 11 includes a throttle position sensor 74 configured to detect the opening degree of the throttle valve 45. Hereinafter, the opening degree of the throttle valve 45 is referred to as a "throttle opening degree". The throttle position sensor 74 is configured to detect the position of the throttle valve 45, and to output a signal indicating the detected position, i.e., the throttle opening degree. The throttle position sensor 74 is equivalent to a close-to-combustion-chamber throttle position sensor in the present teaching.

[0046] A bypass valve 46 is provided to the bypass intake passage member 41 b. The bypass valve 46 is provided to adjust the flow rate of air flowing through the bypass intake passage member 41 b. The bypass valve 46 is manually operated. The bypass valve 46 is formed by an adjust screw, for example. A valve mechanism configured so that its opening degree is controlled by a later-described ECU 80 is not provided to the bypass intake passage member 41 b.

[0047] An intake pressure sensor configured to detect internal pressure in the intake passage member 41 is not provided in the intake passage member 41. The internal pressure in the intake passage member 41 is called intake pressure. An intake temperature sensor configured to detect temperature in the intake passage member 41 is not provided in the intake passage member 41. The temperature of air in the intake passage member 41 is called intake temperature.

[0048] The catalyst 53 is provided in the exhaust passage member 51. The catalyst 53 is equivalent to a "close-to-combustion-chamber catalyst" in the present teaching. The catalyst 53 is provided in the exhaust pipe 52 of the exhaust

unit 50 (see FIG. 1). The path formed inside the exhaust passage member 51 is referred to as an exhaust path. A path length of a freely-selected portion of the exhaust passage member 51 means the length of the path formed in the freely-selected portion. As shown in FIG. 2, a path length of a first portion of the exhaust passage member 51, the first portion being from the exhaust port 34 to an upstream end of the catalyst 53, is called a path length D3. A path length of a second portion of the exhaust passage member 51, the second portion being from a downstream end of the catalyst 53 to the atmosphere discharge port 64a, is called a path length D4. The path length D3 is shorter than the path length D4. That is, the catalyst 53 is close to the combustion chamber 30. The volume of the first portion of the exhaust passage member 51, the first portion being from the exhaust port 34 to the upstream end of the catalyst 53, is called a volume V3. The volume of the second portion of the exhaust passage member 51, the second portion being from the downstream end of the catalyst 53 to the atmosphere discharge port 64a, is called a volume V4. The volume V3 is smaller than the volume V4. As shown in FIG. 1, the catalyst 53 is disposed below the engine main body 20.

[0049] The catalyst 53 is a three-way catalyst. The three-way catalyst is configured to convert three substances contained in the exhaust gas: hydrocarbon (HC), carbon monoxide (CO), and nitrogen oxide (NOx), by oxidation or reduction. The catalyst 53 does not have to be the three-way catalyst, and may be configured to convert one or two of the three substances of hydrocarbon, carbon monoxide, and nitrogen oxide. The catalyst 53 does not have to be an oxidation-reduction catalyst. The catalyst 53 may be an oxidation catalyst or a reduction catalyst, which is configured to convert harmful substances by either oxidation or reduction. The catalyst 53 includes a base material to which one or more noble metals having a function of purifying exhaust gas are attached. The catalyst 53 in this embodiment is a catalyst including a metal base material. Alternatively, the catalyst 53 may be a catalyst including a ceramic base material.

[0050] An oxygen sensor 75 is provided to the exhaust passage member 51. The oxygen sensor 75 is provided upstream of the catalyst 53. The oxygen sensor 75 is configured to detect oxygen concentration in the exhaust gas. The oxygen sensor 75 is configured to output a voltage signal indicating the level of the oxygen concentration in the exhaust gas. Specifically, the oxygen sensor 75 is configured to output a high voltage level signal when the air-fuel ratio of the air-fuel mixture is rich, and to output a low voltage level signal when the air-fuel ratio of the air-fuel mixture is lean. "Rich" means that excess fuel is contained in the mixture with respect to a target air-fuel ratio. "Lean" means that excess air is contained in the mixture with respect to the target air-fuel ratio. That is, the reading by the oxygen sensor 75 shows whether the air-fuel ratio of the air-fuel mixture is rich or lean. The oxygen sensor 75 includes a sensor element formed by a solid electrolyte mainly containing zirconia. The sensor element is activated when heated to a high temperature, which enables the oxygen sensor 75 to detect the oxygen concentration. The oxygen sensor 75 may be a linear air/fuel ratio sensor ("linear A/F sensor") configured to output a linear detection signal proportionally to the oxygen concentration in the exhaust gas. The linear A/F sensor is configured to continuously detect the change of the oxygen concentration in the exhaust gas.

[0051] The muffler 54 is included in the exhaust passage member 51, and provided downstream of the catalyst 53. As shown in FIG. 3, the muffler 54 includes: an external cylinder 60; first to third pipes 61 to 63 housed in the external cylinder 60; and a tail pipe 64. The inside of the external cylinder 60 is partitioned by two separators 65 and 66 into three expansion chambers 60a, 60b, and 60c. An end of the first pipe 61 is connected to the exhaust pipe 52 (see FIG. 1). The first pipe 61 is inserted into the third pipe 63 penetrating the separator 65. A gap is created between the outer circumferential surface of the first pipe 61 and the inner circumferential surface of the third pipe 63. The first pipe 61 penetrates the two separators 65 and 66. The other end of the first pipe 61 is in the first expansion chamber 60a. The second pipe 62 penetrates the two separators 65 and 66. The second pipe 62 establishes communication between the first expansion chamber 60a and the second expansion chamber 60b. The third pipe 63 establishes communication between the second expansion chamber 60b and the third expansion chamber 60c. The tail pipe 64 establishes communication between the third expansion chamber 60c and the space outside the external cylinder 60. An end portion of the tail pipe 64 is outside the external cylinder 60. The end portion of the tail pipe 64 forms the atmosphere discharge port 64a. The exhaust gas flows through the first pipe 61, the first expansion chamber 60a, the second pipe 62, the second expansion chamber 60b, the gap between the third pipe 63 and the first pipe 61, the third expansion chamber 60c, and the tail pipe 64, in this order. In the muffler 54, these members form a path along which the exhaust gas flows. The length of the path in the muffler 54 is longer than the maximum length of the muffler 54. Sound absorption material such as glass wool may be or may not be provided between the inner surface of the external cylinder 60 and the outer surfaces of the pipes 61 to 64. It should be noted that the internal structure of the muffler 54 is not limited to the structure shown in the schematic diagram of FIG. 3.

[0052] As shown in FIG. 4, the air-cooled engine unit 11 includes an ECU (Electronic Control Unit) 80 configured to control the operation of the air-cooled engine unit 11. The ECU 80 is equivalent to a controller in the present teaching. The ECU 80 is connected to various types of sensors such as the engine rotation speed sensor 71, the knocking sensor 72, the engine temperature sensor 73, the throttle position sensor 74, and the oxygen sensor 75. The ECU 80 is also connected to the ignition coil 32, the injector 42, the fuel pump 44, the starter motor 27, the display device 14, and the like.

[0053] The ECU 80 comprises a CPU (central processing unit), a ROM (read-only memory), a RAM (random-access memory), and the like. The CPU executes information processing based on programs and various types of data stored

in the ROM and the RAM. In this way, the ECU 80 implements respective functions of function processors. As shown in FIG. 4, the ECU 80 includes the function processors such as a fuel supply amount controlling unit 81, an ignition timing controlling unit 82, an idle-stop controlling unit 83, and a restart controlling unit 84. The ECU 80 further includes an actuation instructing unit 85. The actuation instructing unit 85 is configured to transmit an actuation instruction signal to the ignition coil 32, the injector 42, the fuel pump 44, the starter motor 27, the generator, the display device 14, or the like, based on the result of the information processing by the function processors. The idle-stop controlling unit 83 and the actuation instructing unit 85 are equivalent to an idle-stop controlling unit in the present teaching. The restart controlling unit 84 and the actuation instructing unit 85 are equivalent to a restart controlling unit in the present teaching.

[0054] The fuel supply amount controlling unit 81 is configured to determine the fuel supply amount of the injector 42. The fuel supply amount is the fuel injection amount in this embodiment. To be more specific, the fuel supply amount controlling unit 81 controls the length of time during which the injector 42 injects fuel. To enhance the combustion efficiency and the exhaust gas purification efficiency by the catalyst 53, it is preferable that the air-fuel ratio of the air-fuel mixture is equal to the stoichiometric air-fuel ratio. The fuel supply amount controlling unit 81 increases or decreases the fuel supply amount as needed. For example, before the completion of warming up of the air-cooled engine unit 11, the fuel supply amount is more than a usual amount. Also, at the time of acceleration, the fuel supply amount is more than the usual amount to increase the engine power of the air-cooled engine unit 11. Meanwhile, at the time of deceleration, the fuel supply amount is reduced.

[0055] As shown in FIG. 5, the fuel supply amount controlling unit 81 includes: a basic fuel supply amount calculating unit 86; a final fuel supply amount calculating unit 87; and an oxygen feedback learning unit 88. The basic fuel supply amount calculating unit 86 is configured to calculate a basic fuel supply amount. The final fuel supply amount calculating unit 87 is configured to correct the basic fuel supply amount calculated by the basic fuel supply amount calculating unit 86, to calculate a final fuel supply amount.

[0056] The basic fuel supply amount calculating unit 86 is configured to calculate the basic fuel supply amount based on a signal from the throttle position sensor 74 and based on a signal from the engine rotation speed sensor 71. The basic fuel supply amount calculating unit 86 is able to calculate the basic fuel supply amount throughout the entire opening-degree range for the opening degree of the throttle valve 45 and throughout the entire rotation-speed range for the engine rotation speed. The basic fuel supply amount calculating unit 86 is configured to calculate the basic fuel supply amount based on the above-mentioned two signals, wherever the signals are in the respective entire ranges mentioned above. To be more specific, a map illustrated in FIG. 6 is used to calculate the basic fuel supply amount. The map shown in FIG. 6 contains values for an intake air amount (A11, A12, ..., A1n, A21, A22, ..., Am1, Am2, ..., Amn), associated with values for the throttle opening degree (K1, K2, ..., Km) and with values for the engine rotation speed (C1, C2, ..., Cn). The intake air amount is a mass flow rate of intake air. In this map, the values for the intake air amount are set for the entire opening-degree range for the throttle opening degree and for the entire rotation-speed range for the engine rotation speed. This map and later-described other maps are stored in the ROM. First of all, the basic fuel supply amount calculating unit 86 obtains the intake air amount with reference to the map of FIG. 6. Then, the basic fuel supply amount calculating unit 86 determines a basic fuel supply amount that achieves a target air-fuel ratio in combination with the intake air amount obtained from the map. FIG. 7 is a graph illustrating an example of the relationship between the throttle opening degree, the engine rotation speed, and the basic fuel supply amount.

[0057] The final fuel supply amount calculating unit 87 includes: an oxygen sensor correction cancelling unit 89; an oxygen sensor correcting unit 90; an oxygen feedback learning correcting unit 91; and an engine temperature sensor correcting unit 92. The oxygen sensor correcting unit 90 is configured to correct the basic fuel supply amount based on a signal from the oxygen sensor 75. Control of the fuel supply amount based on a signal from the oxygen sensor 75 is called "oxygen feedback control".

[0058] The oxygen sensor correction cancelling unit 89 is configured to determine whether to temporarily cancel the correction to the basic fuel supply amount made by the oxygen sensor correcting unit 90. That is, the oxygen sensor correction cancelling unit 89 is configured to determine whether to temporarily cancel the oxygen feedback control. The above determination is made based on the signal from the throttle position sensor 74 and based on the signal from the engine rotation speed sensor 71.

[0059] To be more specific, a map shown in FIG. 8 is used for the above determination. The map of FIG. 8 shows an oxygen feedback control area associated with the values for the throttle opening degree and with the values for the engine rotation speed. The oxygen feedback control area is shown as hatching in FIG. 8. As shown in FIG. 8, the oxygen feedback control area does not include an area corresponding to particularly large values for the throttle opening degree. Furthermore, the oxygen feedback control area does not include an area corresponding to particularly low values for the throttle opening degree and to large values for the engine rotation speed.

[0060] The oxygen sensor correction cancelling unit 89 determines whether a point indicated by the signal from the throttle position sensor 74 and the signal from the engine rotation speed sensor 71 is included in the oxygen feedback control area. When the point indicated by the two signals is not included in the oxygen feedback control area, the oxygen sensor correction cancelling unit 89 determines to cancel the correction. Meanwhile, when the point indicated by the

two signals is included in the oxygen feedback control area, the oxygen sensor correction cancelling unit 89 determines not to cancel the correction.

[0061] When determining to cancel the correction, the oxygen sensor correction cancelling unit 89 cancels the correction by the oxygen sensor correcting unit 90. To cancel the correction by the oxygen sensor correcting unit 90 is to, specifically, prevent the oxygen sensor correcting unit 90 from performing arithmetic processing. Note that the cancellation of the correction by the oxygen sensor correcting unit 90 may be performed in an alternative way. That is, the oxygen sensor correcting unit 90 may perform arithmetic processing using a correction value which is not based on the signal from the oxygen sensor 75 so that the result of the arithmetic processing is equal to the value before the correction. For example, if the oxygen sensor correcting unit 90 is programmed to add a correction value to the basic fuel supply amount in the arithmetic processing, zero may be assigned to the correction value to cancel the correction.

[0062] When the oxygen sensor correction cancelling unit 89 determines not to cancel the correction, the oxygen sensor correcting unit 90 corrects the basic fuel supply amount. As described above, the oxygen sensor correcting unit 90 corrects the basic fuel supply amount based on the signal from the oxygen sensor 75. To be more specific, when the signal from the oxygen sensor 75 indicates that the mixture is lean, the basic fuel supply amount is corrected so that the amount of fuel to be supplied next increases. Meanwhile, when the signal from the oxygen sensor 75 indicates that the mixture is rich, the basic fuel supply amount is corrected so that the amount of fuel to be supplied next decreases.

[0063] When the oxygen sensor correction cancelling unit 89 cancels the correction by the oxygen sensor correcting unit 90, the oxygen feedback learning correcting unit 91 corrects the basic fuel supply amount. The oxygen feedback learning correcting unit 91 corrects the basic fuel supply amount based on an oxygen feedback environment learning correction value and based on an oxygen feedback bypass valve learning correction value, which is described later.

[0064] The result obtained by correcting the basic fuel supply amount by the oxygen sensor correcting unit 90 or the oxygen feedback learning correcting unit 91 is referred to as a "corrected fuel supply amount". The engine temperature sensor correcting unit 92 corrects the corrected fuel supply amount or the basic fuel supply amount, based on a signal from the engine temperature sensor 73. The final fuel supply amount calculating unit 87 adopts the value obtained through correction by the engine temperature sensor correcting unit 92 as a final fuel supply amount. The actuation instructing unit 85 actuates the fuel pump 44 and the injector 42 based on the final fuel supply amount calculated by the final fuel supply amount calculating unit 87.

[0065] The air-cooled engine unit 11 of this embodiment does not include an intake pressure sensor. Because of this, a change in atmospheric pressure caused by a change in altitude, for example, is not directly reported to the ECU 80. However, the change in atmospheric pressure causes a change in the intake air amount. Furthermore, the opening degree of the bypass valve 46 provided to the bypass intake passage member 41 b is not directly reported to the ECU 80. However, under conditions where the throttle opening degree is small, a large influence is made on the intake air amount by the change in the opening degree of the bypass valve 46. Note that, under conditions where the throttle opening degree is large, a smaller influence is made on the intake air amount by the change in the opening degree of the bypass valve 46.

[0066] When the oxygen feedback control is performed, the fuel supply amount is properly controlled to address the change in the intake air amount due to the change in atmospheric pressure or due to the change in the opening degree of the bypass valve 46. However, in order to properly control the fuel supply amount without the oxygen feedback control, a correction has to be made to address the change in atmospheric pressure and the change in the opening degree of the bypass valve 46. For this reason, the oxygen feedback learning unit 88 is provided in this embodiment, to address the change in atmospheric pressure and the change in the opening degree of the bypass valve 46 in the control of the fuel supply amount. The oxygen feedback learning unit 88 is configured to perform oxygen feedback learning. The oxygen feedback learning includes oxygen feedback environment learning in which change in atmospheric pressure is learned. The oxygen feedback learning further includes oxygen feedback bypass valve learning in which change in the opening degree of the bypass valve 46 is learned. That is, the oxygen feedback learning includes the oxygen feedback environment learning and the oxygen feedback bypass valve learning. The oxygen feedback learning unit 88 performs each of the oxygen feedback environment learning and the oxygen feedback bypass valve learning once per driving cycle of the air-cooled engine unit 11. In other words, each learning is performed once during the period from the startup to the stop of the air-cooled engine unit 11.

[0067] A map shown in FIG. 9 is used for the oxygen feedback learning. The map of FIG. 9 shows an oxygen feedback environment learning area associated with the values for the throttle opening degree and with the values for the engine rotation speed. The map of FIG. 9 also shows an oxygen feedback bypass valve learning area associated with the values for the throttle opening degree and with the values for the engine rotation speed. The oxygen feedback environment learning area and the oxygen feedback bypass valve learning area are shown as hatching. The oxygen feedback environment learning area and the oxygen feedback bypass valve learning area are included in the oxygen feedback control area shown in FIG. 8.

[0068] After the startup of the air-cooled engine unit 11, the oxygen feedback learning unit 88 determines whether the point indicated by a signal from the engine rotation speed sensor 71 and a signal from the throttle position sensor 74 is

within the oxygen feedback environment learning area. When the point indicated by the two signals is within the oxygen feedback environment learning area, the oxygen feedback learning unit 88 performs the oxygen feedback environment learning. To be more specific, the oxygen feedback learning unit 88 calculates the difference between: the final fuel supply amount obtained through the oxygen feedback control; and the basic fuel supply amount obtained with reference to the map shown in FIG. 6. This difference is stored in the ROM or RAM as an oxygen feedback environment learning value. The oxygen feedback learning unit 88 compares the obtained oxygen feedback environment learning value with one of the stored oxygen feedback environment learning values. The two compared values correspond to the same throttle opening degree and the same engine rotation speed. When there is a difference between the two compared values, it is concluded that there is a change in atmospheric pressure. Accordingly, when there is a difference between the two compared values, the oxygen feedback learning unit 88 calculates an oxygen feedback environment learning correction value. The oxygen feedback environment learning correction value is calculated based on the difference between the compared two oxygen feedback environment learning values. The oxygen feedback learning correcting unit 91 corrects the basic fuel supply amount based on the calculated oxygen feedback environment learning correction value.

[0069] After the startup of the air-cooled engine unit 11, the oxygen feedback learning unit 88 determines whether the point indicated by the signal from the engine rotation speed sensor 71 and the signal from the throttle position sensor 74 is within the oxygen feedback bypass valve learning area. When the point indicated by the two signals is within the oxygen feedback bypass valve learning area, the oxygen feedback learning unit 88 performs the oxygen feedback bypass valve learning. To be more specific, the oxygen feedback learning unit 88 calculates the difference between: the final fuel supply amount obtained through the oxygen feedback control; and the basic fuel supply amount obtained with reference to the map shown in FIG. 6. This difference is stored in the ROM or RAM as an oxygen feedback bypass valve learning value. The oxygen feedback learning unit 88 compares the obtained oxygen feedback bypass valve learning value with one of the stored oxygen feedback bypass valve learning values. The two compared values correspond to the same throttle opening degree and the same engine rotation speed. When there is a difference between the two compared values, it is concluded that there is a change in the opening degree of the bypass valve 46. Accordingly, when there is a difference between the two compared values, the oxygen feedback learning unit 88 calculates an oxygen feedback bypass valve learning correction value. The oxygen feedback bypass valve learning correction value is calculated based on the difference between the compared two oxygen feedback bypass valve learning values. The oxygen feedback learning correcting unit 91 corrects the basic fuel supply amount based on the calculated oxygen feedback bypass valve learning correction value.

[0070] The ignition timing controlling unit 82 is configured to calculate the ignition timing. The ignition timing is the timing at which the spark plug 31 produces an electrical spark. The ignition timing is expressed in rotation angles of the crankshaft 26 taking the compression top dead center as a reference. The compression top dead center is the top dead center for the piston 28 shifting from the compression stroke to the combustion stroke. The minimum advance with which the best torque is achieved is called the minimum advance for the best torque (MBT). Hereinafter, an advance near the MBT may be expressed as "the ignition timing is close to the MBT". Furthermore, an advance in retard of the MBT may be expressed as "the ignition timing is in retard of the MBT", for example. The MBT is the best ignition timing to enhance the fuel economy and engine power. However, knocking is more likely to occur at the MBT. For this reason, the ignition timing is retarded relative to the MBT. Besides, the ignition timing is controlled to be brought as close to the MBT as possible while large knocking is prevented.

[0071] The ignition timing controlling unit 82 includes a basic ignition timing calculating unit 93 and a final ignition timing calculating unit 94. The basic ignition timing calculating unit 93 is configured to calculate basic ignition timing. The final ignition timing calculating unit 94 is configured to correct the value of the basic ignition timing obtained by the basic ignition timing calculating unit 93, to calculate final ignition timing.

[0072] The basic ignition timing calculating unit 93 is configured to calculate the basic ignition timing based on the signal from the throttle position sensor 74 and based on the signal from the engine rotation speed sensor 71. The basic ignition timing calculating unit 93 is able to calculate the basic ignition timing throughout the entire opening-degree range for the opening degree of the throttle valve 45 and throughout the entire rotation-speed range for the engine rotation speed. The basic ignition timing calculating unit 93 is configured to calculate the basic ignition timing based on the above-mentioned two signals, wherever the signals are in the respective entire ranges mentioned above. To be more specific, the basic ignition timing calculating unit 93 obtains the basic ignition timing using a map (not illustrated) containing values for the basic ignition timing associated with the throttle opening degree and with the engine rotation speed. In this map, the values for the basic ignition timing are set for the entire opening-degree range for the throttle opening degree and for the entire rotation-speed range for the engine rotation speed. FIG. 10 is a graph illustrating an example of the relationship between the throttle opening degree, the engine rotation speed, and the basic ignition timing.

[0073] The final ignition timing calculating unit 94 includes a knocking sensor correction cancelling unit 95, a knocking sensor correcting unit 96, and an engine temperature sensor correcting unit 97. The knocking sensor correcting unit 96 is configured to correct the basic ignition timing based on a signal from the knocking sensor 72. The control of the ignition

timing based on the signal from the knocking sensor 72 is called "knocking control". The knocking sensor correction cancelling unit 95 is configured to determine whether to cancel the correction by the knocking sensor correcting unit 96. That is, the knocking sensor correction cancelling unit 95 determines whether to perform the knocking control. The above determination is made based on the signal from the throttle position sensor 74 and based on the signal from the engine rotation speed sensor 71.

[0074] To be more specific, a map shown in FIG. 11 is used for the above determination. The map of FIG. 11 shows a knocking control area associated with the values for the throttle opening degree and with the values for the engine rotation speed. The knocking control area is shown as hatching. As shown in FIG. 11, the knocking control area corresponds to particularly large values for the throttle opening degree. That is, the engine load is high in the knocking control area.

[0075] The knocking sensor correction cancelling unit 95 determines whether a point indicated by the signal from the throttle position sensor 74 and the signal from the engine rotation speed sensor 71 is included in the knocking control area. When the point indicated by the two signals is not included in the knocking control area, the knocking sensor correction cancelling unit 95 determines to cancel the correction. Meanwhile, when the point indicated by the two signals is included in the knocking control area, the knocking sensor correction cancelling unit 95 determines not to cancel the correction.

[0076] When determining to cancel the correction, the knocking sensor correction cancelling unit 95 cancels the correction by the knocking sensor correcting unit 96. To cancel the correction by the knocking sensor correcting unit 96 is to, specifically, prevent the knocking sensor correcting unit 96 from performing arithmetic processing. Note that the cancellation of the correction by the knocking sensor correcting unit 96 may be performed in an alternative way. That is, the knocking sensor correcting unit 96 may perform arithmetic processing using a correction value which is not based on the signal from the knocking sensor 72 so that the result of the arithmetic processing is equal to the value before the correction.

[0077] When the knocking sensor correction cancelling unit 95 determines not to cancel the correction, the knocking sensor correcting unit 96 corrects the basic ignition timing. The knocking sensor correcting unit 96 is configured to correct the basic ignition timing based on a signal from the knocking sensor 72. To be more specific, the knocking sensor correcting unit 96 determines the presence or absence of knocking in the engine main body 20 based on the signal from the knocking sensor 72. The presence or absence of knocking is determined based on a peak value of the signal from the knocking sensor 72, for example. When it is determined that knocking is present, the knocking sensor correcting unit 96 corrects the basic ignition timing by retarding the ignition timing by a predetermined retard angle. Meanwhile, when it is determined that knocking is absent, the knocking sensor correcting unit 96 corrects the basic ignition timing by advancing the ignition timing by a predetermined advance angle. In this way, each time the correction is made under conditions where knocking is absent, the ignition timing is advanced by a predetermined advance angle towards the MBT. Meanwhile, each time the correction is made under conditions where knocking is present, the ignition timing is retarded, relative to the MBT, by a predetermined retard angle. As a consequence, occurrence of knocking is suppressed. Accordingly, while large knocking is prevented, the engine power and fuel economy are improved by bringing the ignition timing as close to the MBT as possible.

[0078] The result obtained by correcting the basic ignition timing by the knocking sensor correcting unit 96 is referred to as a "corrected ignition timing". The engine temperature sensor correcting unit 97 corrects the corrected ignition timing or the basic ignition timing, based on the signal from the engine temperature sensor 73. The final ignition timing calculating unit 94 adopts the value obtained through the correction by the engine temperature sensor correcting unit 97 as a final ignition timing. The actuation instructing unit 85 energizes the ignition coil 32 to actuate the spark plug 31, based on the final ignition timing calculated by the final ignition timing calculating unit 94.

[0079] The air-cooled engine unit 11 of this embodiment does not include an intake pressure sensor. Because of this, a change in atmospheric pressure caused by a change in altitude, for example, is not directly reported to the ECU 80. However, knocking control is performed in the knocking control area, and this enables the ignition timing to be brought as close to the MBT as possible even when there is a change in atmospheric pressure. Thus, fuel economy and engine power are enhanced.

[0080] The idle-stop controlling unit 83 is configured to stop the air-cooled engine unit 11 from running when a predetermined idle-stop condition is satisfied during the running of the air-cooled engine unit 11. The state of the air-cooled engine unit 11, in which the air-cooled engine unit 11 has been automatically stopped from running by the idle-stop controlling unit 83, is referred to as an "idle-stop state". When the predetermined idle-stop condition is satisfied, the idle-stop controlling unit 83 gives the actuation instructing unit 85 an instruction as follows. The instruction is to stop the spark plug 31 from igniting the mixture and to stop the injector 42 from supplying fuel. By this instruction, the air-cooled engine unit 11 is stopped from running.

[0081] The idle-stop condition of this embodiment is that the state in which all the below-described conditions A1 to A6 are satisfied lasts for a predetermined period of time. The predetermined period of time is, for example, 3 seconds. The conditions A1 to A6 are as follows:

A1: the throttle opening degree is within a predetermined idle opening degree range (for example, less than 0.3 degrees);

A2: the vehicle speed is equal to or lower than a predetermined speed (for example, 3 km/h);

A3: the engine rotation speed is within a predetermined idle rotation speed range (for example, equal to or lower than 2000 rpm);

A4: the engine temperature is equal to or higher than a predetermined temperature (e.g., 60 degrees Celsius);

A5: the remaining power of the battery is equal to or larger than a predetermined value; and

A6: the oxygen feedback bypass valve learning is not performed.

[0082] During an idle-stop time, that is, while the air-cooled engine unit 11 is in the idle-stop state, a corresponding indicator on the display device 14 illuminates under the control by the ECU 80. The illuminating indicator notifies the rider that the air-cooled engine unit 11 is in the idle-stop state. Furthermore, during the idle-stop time, the piston 28 stops at or in the vicinity of the bottom dead center. During the idle-stop time, the ECU 80 controls the injector 42 so as to inject fuel.

[0083] The restart controlling unit 84 is configured to restart the air-cooled engine unit 11 to get the engine unit 11 to run when a predetermined restart condition is satisfied during the idle-stop time. The restart condition in the present embodiment is that the throttle opening degree becomes equal to or larger than a predetermined throttle opening degree. Therefore, the air-cooled engine unit 11 is able to be restarted by the rider twisting the throttle grip (not illustrated).

[0084] When the predetermined restart condition is satisfied, the restart controlling unit 84 gives an instruction to the actuation instructing unit 85 to actuate the starter motor 27. As a result, the starter motor 27 is actuated. Furthermore, when the predetermined restart condition is satisfied, the restart controlling unit 84 causes the fuel supply amount controlling unit 81 and the ignition timing controlling unit 82 to start their controls. As a result, fuel is injected from the injector 42, and an electrical spark is produced by the spark plug 31. Thus, the air-cooled engine unit 11 is restarted to get the engine unit 11 to run. To be more specific, the ignition timing controlling unit 82 controls the ignition timing so that the fuel that has been supplied to the combustion chamber 30 during the idle-stop time is ignited the first time the piston 28 reaches the compression top dead center after the starter motor 27 is actuated. This enables rapid restart of the air-cooled engine unit 11. Furthermore, noise of the starter motor 27 at the time of the restart is suppressed.

[0085] While the air-cooled engine unit 11 is in the idle-stop state, the throttle opening degree is approximately at a fully-closed level. Because of this, the throttle opening degree and the engine rotation speed at the time of the restart of the engine unit in the idle-stop state are not included in the knocking control area. This eliminates complexity from the control of the ignition timing at the time of the restart.

[0086] As described above, the compression ratio of the engine main body 20 of this embodiment is 10 or higher. Table 1 shows, by way of example, the temperature of exhaust gas in an air-cooled engine unit having a compression ratio of 11, and the temperature of exhaust gas in an air-cooled engine unit having a compression ratio of 9.5. Exhaust temperatures in Table 1 represent the temperatures of the exhaust gas at the time when the exhaust gas is discharged from the respective engine main bodies. As clearly seen from Table 1, the higher the compression ratio is, the lower the temperature of the exhaust gas is. This is because the higher the compression ratio is, the higher the heat efficiency is.

[Table 1]

		EXHAUST TEMPERATURE (°C)
EXAMPLE	COMPRESSION RATIO: 11	470
COMPARATIVE EXAMPLE	COMPRESSION RATIO: 9.5	550

[0087] In this embodiment, the air-cooled engine unit 11 stops running when the predetermined idle-stop condition is satisfied. While the engine unit is idling i.e., in an idle running state, its engine rotation speed is lower and therefore the exhaust gas in this state has a lower temperature. Suppose that the idle running state continues after the transition from the normal running state to the idle running state. If so, the temperature of the catalyst 53 is lowered because the exhaust gas having the lower temperature passes through the catalyst 53. Normally, the temperature of the exhaust gas is lower in air-cooled engine units, as described above. For this reason, the temperature of the exhaust gas is quite low in the air-cooled engine unit in the idle running state. Thus, during the idle time, there is a possibility that the temperature of the catalyst 53 drops to the extent that the catalyst 53 is deactivated. In the present embodiment, however, the air-cooled engine unit 11 stops running when the predetermined idle-stop condition is satisfied, and this prevents the exhaust gas having such a low temperature from passing through the catalyst 53. This enables the catalyst 53 to be kept at a high temperature, to keep the catalyst 53 activated.

[0088] Table 2 below shows, by way of example, comparison between: temperatures of exhaust gas and the catalyst in the case where idle running state is stopped; and those in the case where the idle running state is not stopped. The

row of "Example" in Table 2 contains data obtained 20 seconds after the idle running state is stopped. In this Example, the idle running state was stopped after the transition from the normal running state to the idle running state. The row of "Comparative Example" in Table 2 contains data obtained 20 seconds after the transition from the normal running state to the idle running state. First Temperature in Table 2 represents the temperature of the exhaust gas in a part of the exhaust passage member, the part being close to the engine main body. Second Temperature in Table 2 represents the temperature of the exhaust gas in a part of the exhaust passage member, the part being upstream of the catalyst and close to the catalyst. As clearly seen from Table 2, the catalyst is kept at a higher temperature in the case where the idle running state is stopped, than in the case where the idle running state continues.

[Table 2]

		FIRST TEMPERATURE (°C)	SECOND TEMPERATURE (°C)	CATALYST TEMPERATURE (°C)
EXAMPLE	WITH IDLE STOP	300	270	430
COMPARATIVE EXAMPLE	NO IDLE STOP	500	300	380

[0089] The air-cooled engine unit 11 of the present embodiment has the following characteristics.

[0090] The path length D3 of the first portion of the exhaust passage member 51, the first portion being from the exhaust port 34 to the catalyst 53, is shorter than the path length D1 of the second portion of the exhaust passage member 51, the second portion being from the catalyst 53 to the atmosphere discharge port 64a. That is, the catalyst 53 is provided close to the engine main body 20. This enables reduction in the time needed for activation of the catalyst 53.

[0091] Generally, in air-cooled engines, the temperature of the engine main body tends to be higher than in water-cooled engines. In this regard, however, the engine main body 20 of the air-cooled engine unit 11 of this embodiment has a compression ratio of 10 or higher, which is higher than those in known air-cooled engine units. Due to the high compression ratio, the exhaust gas discharged from the combustion chamber 30 has a lower temperature. Because of this, even though the catalyst 53 is provided close to the engine main body 20, the temperature of the exhaust gas flowing into the catalyst 53 is lower. Thus, the deterioration of the catalyst 53 due to overheating can be minimized even though the catalyst 53 is provided close to the engine main body 20.

[0092] The idle-stop controlling unit 83 is configured to automatically stop the air-cooled engine unit 11 from running when the predetermined idle-stop condition is satisfied during the running of the air-cooled engine unit 11. The restart controlling unit 84 is configured to restart the air-cooled engine unit 11 to get the engine unit 11 to run when the predetermined restart condition is satisfied in a situation in which the air-cooled engine unit 11 has been stopped from running by the idle-stop controlling unit 83. That is, when the predetermined idle-stop condition is satisfied during an idle time in which the air-cooled engine unit 11 is idling, the air-cooled engine unit 11 is stopped from running automatically. When the predetermined restart condition is satisfied thereafter, the air-cooled engine unit 11 is restarted.

[0093] During the idle time, the temperature of the exhaust gas discharged from the combustion chamber 30 is lower. The air-cooled engine unit 11 of this embodiment has the high compression ratio. Because of this, exhaust gas discharged from the combustion chamber 30 of this engine unit during the idle time has a further lower temperature. In the air-cooled engine unit 11 of this embodiment, the idle-stop control is performed, and this prevents a long-time duration of the idle state. This also prevents a drop of the temperature of the catalyst 53 below its activation temperature. As a result, improvement in exhaust gas purification performance is achievable.

[0094] The ECU 80 is configured to control the ignition timing of the spark plug 31, which is configured to ignite fuel in the combustion chamber 30, based on a signal from the knocking sensor 72. To be more specific, the ECU 80 retards the ignition timing when knocking is detected. This prevents occurrence of large knocking.

[0095] Knocking is more likely to occur in the engine main body 20 having the high compression ratio. However, the air-cooled engine unit 11 of the present embodiment includes the knocking sensor 72, and the ignition timing is retarded if knocking occurs. This eliminates the necessity for extra retard of the ignition timing as a precaution against knocking. In other words, the amount of retard of the ignition timing is reducible. The reduction of the amount of retard lowers the temperature of the exhaust gas discharged from the combustion chamber 30. Thus, it is possible to lower the temperature of the exhaust gas while minimizing the amount of retard of the ignition timing. As a consequence, the deterioration of the catalyst 53 due to overheating can be minimized, with sufficient torque.

[0096] The ECU 80 is configured to control the fuel supply amount of the injector 42 based on a signal from the oxygen sensor 75. The high compression ratio of the engine main body 20 results in low temperature of the exhaust gas. The low temperature of the exhaust gas lowers the temperature of the oxygen sensor 75 provided to the exhaust passage

member 51. If the temperature of the oxygen sensor 75 drops too low, the oxygen sensor 75 is deactivated. This reduces the detection accuracy of the oxygen sensor 75. However, the oxygen sensor 75 in the present embodiment is provided upstream of the catalyst 53 provided close to the engine main body 20. That is, the oxygen sensor 75 is provided even closer to the engine main body 20 than the catalyst 53. This arrangement enables the exhaust gas in contact with the oxygen sensor 75 to have a higher temperature. That is, this arrangement makes the temperature drop of the oxygen sensor 75 smaller. Thus, the oxygen sensor 75 is kept activated. As a consequence, the precision of the control of the fuel supply amount is maintained.

[0097] The path length D1 of the first portion of the intake passage member 41, the first portion being from the atmosphere suction port 41 c to the throttle valve 45, is longer than the path length D2 of the second portion of the intake passage member 41, the second portion being from the throttle valve 45 to the intake port 33. That is, the throttle valve 45 is provided close to the combustion chamber 30. Due to this, there is less delay in the change of the amount of air taken into the combustion chamber 30, in relation to the change in the opening degree of the throttle valve 45. The ECU 80 is configured to control the fuel supply amount of the injector 42 and to control the ignition timing of the spark plug 31, based on a signal from the throttle position sensor 74. Because of this, there is less delay in the change of the fuel supply amount and in the change of the ignition timing, in relation to the change in the opening degree of the throttle valve 45. As described above, there is less delay in the change of the amount of air taken into the combustion chamber 30, in relation to the change in the opening degree of the throttle valve 45. Due to this, when the opening degree of the throttle valve 45 changes, there is a small time lag between: the change of each of the fuel supply amount and the ignition timing in response to the change in the valve opening degree; and the change of the amount of air taken into the combustion chamber in response to the change in the valve opening degree. This enables improvement in the precision of the control of the fuel supply amount and the ignition timing.

[0098] The improvement in the precision of the control of the ignition timing also provides the following advantageous effect. Specifically, it is possible to reduce the extra retard of the ignition timing as a precaution against knocking even if the knocking sensor 72 is not provided. Due to the reduction of the extra retard, the temperature of the exhaust gas is lowered while the amount of retard of the ignition timing is minimized. As a consequence, the deterioration of the close-to-combustion-chamber catalyst due to overheating can be minimized, with sufficient torque.

[0099] The air-cooled engine unit 11 does not include an intake pressure sensor configured to detect internal pressure in the intake passage member 41. Furthermore, the air-cooled engine unit 11 does not include an intake temperature sensor configured to detect the temperature in the intake passage member 41. Because of these, intake pressure and intake temperature are not used to control the fuel supply amount and the ignition timing. This makes the control of the fuel supply amount and the control of the ignition timing simpler.

[0100] A preferred embodiment of the present teaching has been described above. It should be noted that the present teaching is not limited to the above-described embodiment, and various changes can be made within the scope of the claims. Further, modifications described later may be used in combination as needed. It is noted that the term "preferable" used herein is non-exclusive and means "preferable but not limited to".

[0101] The final fuel supply amount calculating unit 87 may include one or more correcting units configured to correct the fuel supply amount other than the oxygen sensor correcting unit 90 and the engine temperature sensor correcting unit 92. For example, the final fuel supply amount calculating unit 87 may have a correcting unit configured to correct the fuel supply amount in accordance with transient characteristics at the time of acceleration/deceleration.

[0102] The final ignition timing calculating unit 94 may include one or more correcting units configured to correct the ignition timing other than the knocking sensor correcting unit 96 and the engine temperature sensor correcting unit 97. Alternatively, the final ignition timing calculating unit 94 does not have to include the engine temperature sensor correcting unit 97.

[0103] In the above-described embodiment, the air-cooled engine unit 11 is stopped from running when the predetermined idle-stop condition is satisfied during the idle time. However, the air-cooled engine unit 11 does not have to be stopped from running during the idle time. That is to say, the ECU 80 does not have to include the idle-stop controlling unit 83 and the restart controlling unit 84.

[0104] While the catalyst 53 is provided below the engine main body in the above-described embodiment, the location of the catalyst 53 is not limited to this. The catalyst 53 may be provided at another location as long as the path length D3 is shorter than the path length D4. The catalyst 53 may be provided in front of the engine main body 20.

[0105] In addition to the above, a plurality of catalysts may be provided in the exhaust passage member 51. In this alternative, out of the plurality of catalysts, the catalyst that purifies the exhaust gas discharged from the combustion chamber 30 most in each of one or more exhaust paths is equivalent to the close-to-combustion-chamber catalyst in the present teaching. That is, the close-to-combustion-chamber catalyst has the highest degree of contribution to the purification of the exhaust gas. The remaining one or more catalysts are provided upstream or downstream of the close-to-combustion-chamber catalyst.

[0106] The purification contribution levels of the catalysts are measurable by the following way.

[0107] Herein, an explanation is given for the case in which the number of the catalysts is two, by way of example.

Out of the two catalysts, the catalyst provided upstream is referred to as a front catalyst, and the catalyst provided downstream is referred to as a rear catalyst. First of all, an engine unit of this modification is run, and in a warmed-up state, the concentrations of harmful substances contained in the exhaust gas discharged through the atmosphere discharge port 64a of the engine unit are measured. The method of measuring the concentrations of harmful substances in the exhaust gas is in compliance with European regulations. In the warm-up state, the two catalysts have been activated, and their purification abilities are fully exercised.

[0108] Then, the rear catalyst is detached from the test engine unit, and only a base material of the rear catalyst is provided in place of the rear catalyst. The engine unit in this state is assumed as a "measurement engine unit A". The measurement engine unit A is run, and in the warm-up state, the concentrations of the harmful substances contained in the exhaust gas discharged through the atmosphere discharge port 64a are measured.

[0109] Then, the front catalyst is detached from the measurement engine unit A, and only a base material of the front catalyst is provided in place of the front catalyst. The engine unit in this state is assumed as a "measurement engine unit B". The measurement engine unit B is run, and in the warm-up state, the concentrations of the harmful substances contained in the exhaust gas discharged through the atmosphere discharge port 64a are measured.

[0110] The measurement engine unit A includes the front catalyst, but does not include the rear catalyst. The measurement engine unit B includes neither the front catalyst nor the rear catalyst. On this account, the degree of contribution to the purification of the front catalyst is calculated from the difference between a measurement result of the measurement engine unit A and a measurement result of the measurement engine unit B. Meanwhile, the degree of contribution to the purification of the rear catalyst is calculated from the difference between the measurement result of the measurement engine unit A and a measurement result of the measurement engine unit of the modification.

[0111] While the injector 42 is arranged to inject fuel into the intake passage member 41 in the above-described embodiment, the injector 42 may be arranged to inject fuel into the combustion chamber 30. The injector 42 may be provided in the engine main body 20.

[0112] In the above-described embodiment, the injector 42 is equivalent to the fuel supplier in the present teaching. However, the fuel supplier in the present teaching is not limited to the injector. The fuel supplier in the present teaching may be another device as long as it is configured to supply fuel into the combustion chamber. For example, the fuel supplier in the present teaching may be a carburetor configured to supply fuel into the combustion chamber by depression.

[0113] In the above-described embodiment, the bypass valve 46, the opening degree of which is manually changeable, is provided to the bypass intake passage member 41b. Instead of the bypass valve 46, an ECU-controlled valve may be provided, the opening degree of which is changeable by the ECU 80.

[0114] The air-cooled engine unit 11 may include an intake pressure sensor configured to detect internal pressure in the intake passage member 41. In this case, a signal from the intake pressure sensor may be used to control the fuel supply amount and/or the ignition timing.

[0115] The air-cooled engine unit 11 may include an intake temperature sensor configured to detect the temperature of air in the intake passage member 41. In this case, a signal from the intake temperature sensor may be used to control the fuel supply amount and/or the ignition timing.

[0116] The air-cooled engine unit 11 does not have to include the knocking sensor 72.

[0117] The air-cooled engine unit 11 of the above-described embodiment is a natural air-cooled engine. In this regard, in the present teaching, the air-cooled engine unit may be a forced air-cooled engine unit. The forced air-cooled engine unit includes a shroud and a fan. The shroud is provided to cover at least a part of the engine main body. As the fan is driven, air is introduced into the inside of the shroud.

[0118] While the engine unit 11 of the above-described embodiment is a single-cylinder engine unit, the air-cooled engine unit of the present teaching may be a multi-cylinder engine unit including a plurality of combustion chambers. In this alternative, the number of atmosphere suction ports 41c may be smaller than the number of the combustion chambers 30. That is to say, a part of the intake passage member 41 for one of the combustion chambers 30 may function as a part of the intake passage member 41 for another one of the combustion chambers 30. The number of the atmosphere suction ports 41c may be one. Furthermore, the number of atmosphere discharge ports 64a may be smaller than the number of the combustion chambers 30. That is to say, a part of the exhaust passage member 51 for one of the combustion chambers 30 may function as a part of the exhaust passage member 51 for another one of the combustion chambers 30. The number of the atmosphere discharge ports 64a may be one. Furthermore, when the number of the combustion chambers 30 is an odd number larger than four, two atmosphere discharge ports 64a may be provided at the left and right, respectively.

[0119] The combustion chamber in the present teaching may include a main combustion chamber and an auxiliary combustion chamber communicating with the main combustion chamber. In this case, the main combustion chamber and the auxiliary combustion chamber constitute the single combustion chamber.

[0120] The above-described embodiment deals with an example in which the air-cooled engine unit of the present teaching is used in a sports motorcycle. In this regard, objects to which the air-cooled engine unit of the present teaching is applied are not limited to sports motorcycles. The air-cooled engine unit of the present teaching may be applied to

motorcycles other than sports motorcycles. For example, the air-cooled engine unit of the present teaching is applicable to scooters, a kind of motorcycle. Moreover, the air-cooled engine unit of the present teaching is applicable to leaning vehicles other than motorcycles. The leaning vehicles are vehicles each having a vehicle body frame which leans to the right of the vehicle when turning right, and leans to the left of the vehicle when turning left. Moreover, the air-cooled engine unit of the present teaching is applicable to straddled vehicles other than motorcycles. The straddled vehicles encompass all the variety of vehicles that a rider rides as if the rider straddles a saddle. The straddled vehicles encompass motorcycles, tricycles, four-wheelers (all-terrain vehicles (ATVs)), personal water crafts, snowmobiles, and the like.

[0121] In this description, the path length of a freely-selected portion of the intake passage member 41 means the length of the path provided in the freely-selected portion. A similar definition is applied to the path length of a freely-selected portion of the exhaust passage member 51. In this description, the path length means the length of the center line of the path. The path length of each expansion chamber (60a, 60b, 60c) of the muffler 54 is the length of the path connecting the center of the inflow port of the expansion chamber with the center of the outflow port of the expansion chamber in the shortest distance. In this description, an upstream end of the catalyst 53 is the end of the catalyst 53, at which the path length from the combustion chamber 30 is the shortest. In this description, a downstream end of the catalyst 53 is the end of the catalyst 53, at which the path length from the combustion chamber 30 is the longest. The upstream ends and the downstream ends of elements other than the catalyst 53 are similarly defined, too.

Reference Signs List

[0122]

- 11: air-cooled engine unit
- 20: engine main body
- 25: fin portion (heat dissipater)
- 30: combustion chamber
- 31: spark plug (ignition device)
- 32: ignition coil (ignition device)
- 33: intake port
- 34: exhaust port
- 41: intake passage member
- 41c: atmosphere suction port
- 42: injector (fuel supplier)
- 45: throttle valve (close-to-combustion-chamber throttle valve)
- 51: exhaust passage member
- 53: catalyst (close-to-combustion-chamber catalyst)
- 64a: atmosphere discharge port
- 71: engine rotation speed sensor
- 72: knocking sensor
- 73: engine temperature sensor
- 74: throttle position sensor (close-to-combustion-chamber throttle position sensor)
- 75: oxygen sensor
- 80: ECU (controller)
- 81: fuel supply amount controlling unit
- 82: ignition timing controlling unit
- 83: idle-stop controlling unit
- 84: restart controlling unit
- 85: actuation instructing unit

Claims

1. An air-cooled engine unit comprising:

- an engine main body having a compression ratio of 10 or higher and forming at least one combustion chamber;
- a heat dissipater configured to dissipate heat generated in the engine main body from a surface of the engine main body;
- an exhaust passage member connecting an exhaust port provided through the combustion chamber with an atmosphere discharge port through which exhaust gas is discharged to the atmosphere, the exhaust gas flowing

inside the exhaust passage member from the exhaust port to the atmosphere discharge port; and
 a close-to-combustion-chamber catalyst provided in the exhaust passage member, wherein
 a path length of a first portion of the exhaust passage member is shorter than a path length of a second portion
 of the exhaust passage member, the first portion of the exhaust passage member being from the exhaust port
 to an upstream end of the close-to-combustion-chamber catalyst, the second portion of the exhaust passage
 member being from a downstream end of the close-to-combustion-chamber catalyst to the atmosphere discharge
 port.

2. The air-cooled engine unit according to claim 1, further comprising
 a controller configured to control operation of the air-cooled engine unit, wherein
 the controller includes:

an idle-stop controlling unit configured to automatically stop the air-cooled engine unit from running when an
 idle-stop condition is satisfied during running of the air-cooled engine unit; and
 a restart controlling unit configured to restart the air-cooled engine unit to get the engine unit to run when a
 restart condition is satisfied in a situation in which the air-cooled engine unit has been stopped from running by
 the idle-stop controlling unit.

3. The air-cooled engine unit according to claim 1 or 2, further comprising:

a knocking sensor configured to detect knocking occurring in the engine main body;
 an ignition device configured to ignite fuel in the combustion chamber; and
 a controller configured to control an ignition timing of the ignition device based on a signal from the knocking
 sensor.

4. The air-cooled engine unit according to any one of claims 1 to 3, further comprising:

an oxygen sensor provided to the exhaust passage member, the oxygen sensor being provided upstream of
 the close-to-combustion-chamber catalyst in a direction of flow of the exhaust gas, and being configured to
 detect oxygen concentration in the exhaust gas in the exhaust passage member;
 a fuel supplier configured to supply fuel into the combustion chamber; and
 a controller configured to control a fuel supply amount of the fuel supplier based on a signal from the oxygen
 sensor.

5. The air-cooled engine unit according to any one of claims 1 to 4, further comprising:

an intake passage member connecting an intake port provided through the combustion chamber with an at-
 mosphere suction port through which air is taken in from the atmosphere, the air flowing inside the intake
 passage member from the atmosphere suction port to the intake port;
 an ignition device configured to ignite fuel in the combustion chamber;
 a fuel supplier configured to supply fuel into the combustion chamber;
 a close-to-combustion-chamber throttle valve provided in the intake passage member, the close-to-combustion-
 chamber throttle valve being positioned so that a path length of a first portion of the intake passage member is
 longer than a path length of a second portion of the intake passage member, the first portion of the intake
 passage member being from the atmosphere suction port to the close-to-combustion-chamber throttle valve,
 the second portion of the intake passage member being from the close-to-combustion-chamber throttle valve
 to the intake port;
 a close-to-combustion-chamber throttle position sensor configured to detect an opening degree of the close-
 to-combustion-chamber throttle valve;
 an engine rotation speed sensor configured to detect engine rotation speed; and
 a controller configured to control a fuel supply amount of the fuel supplier and to control an ignition timing of
 the ignition device based on a signal from the close-to-combustion-chamber throttle position sensor and based
 on a signal from the engine rotation speed sensor.

6. The air-cooled engine unit according to any one of claims 1 to 5, further comprising
 an intake passage member connecting an intake port provided through the combustion chamber with an atmosphere
 suction port through which air is taken in from the atmosphere, the air flowing inside the intake passage member
 from the atmosphere suction port to the intake port, wherein

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the air-cooled engine unit does not include: an intake pressure sensor provided for the intake passage member and configured to detect internal pressure in the intake passage member; and an intake temperature sensor provided for the intake passage member and configured to detect temperature in the intake passage member.

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FIG.1

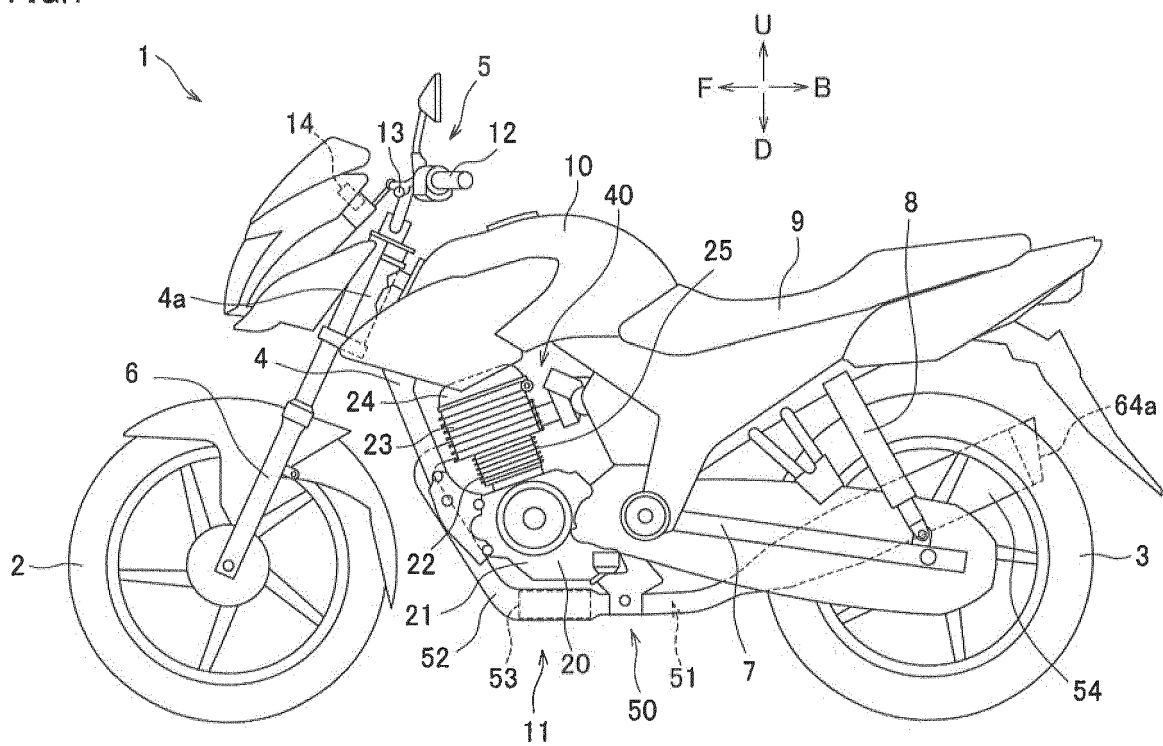


FIG.2

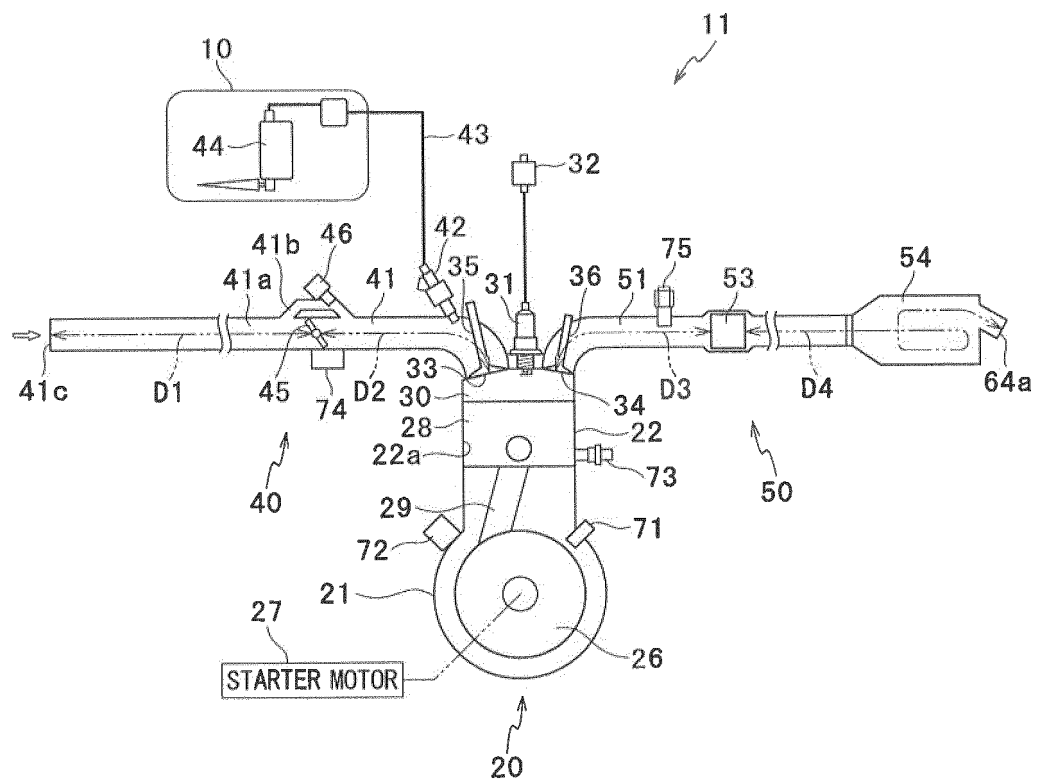


FIG.3

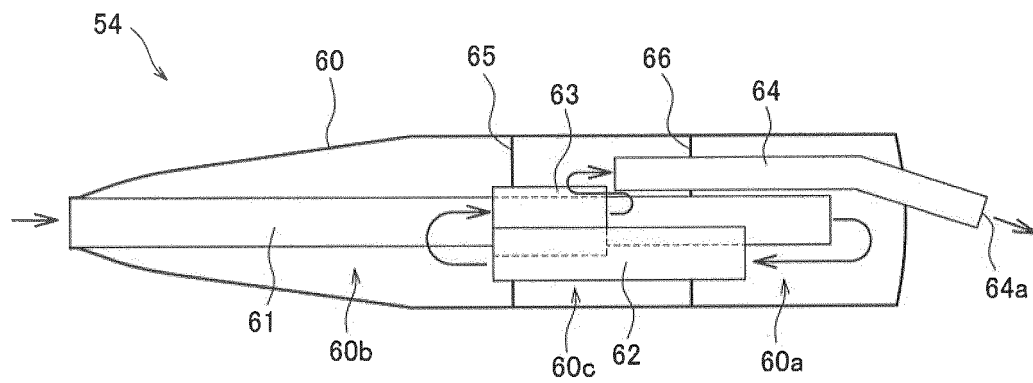


FIG.4

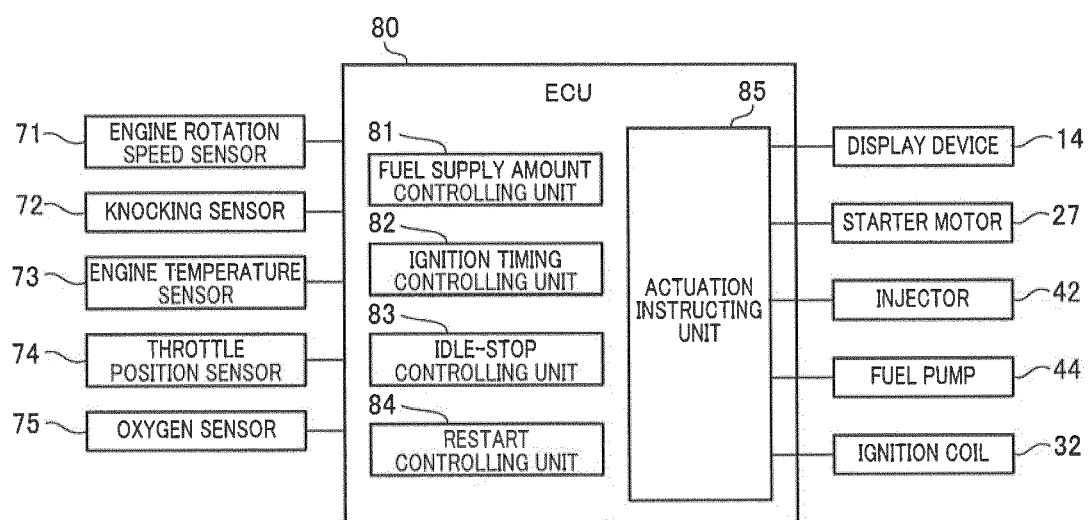


FIG.5

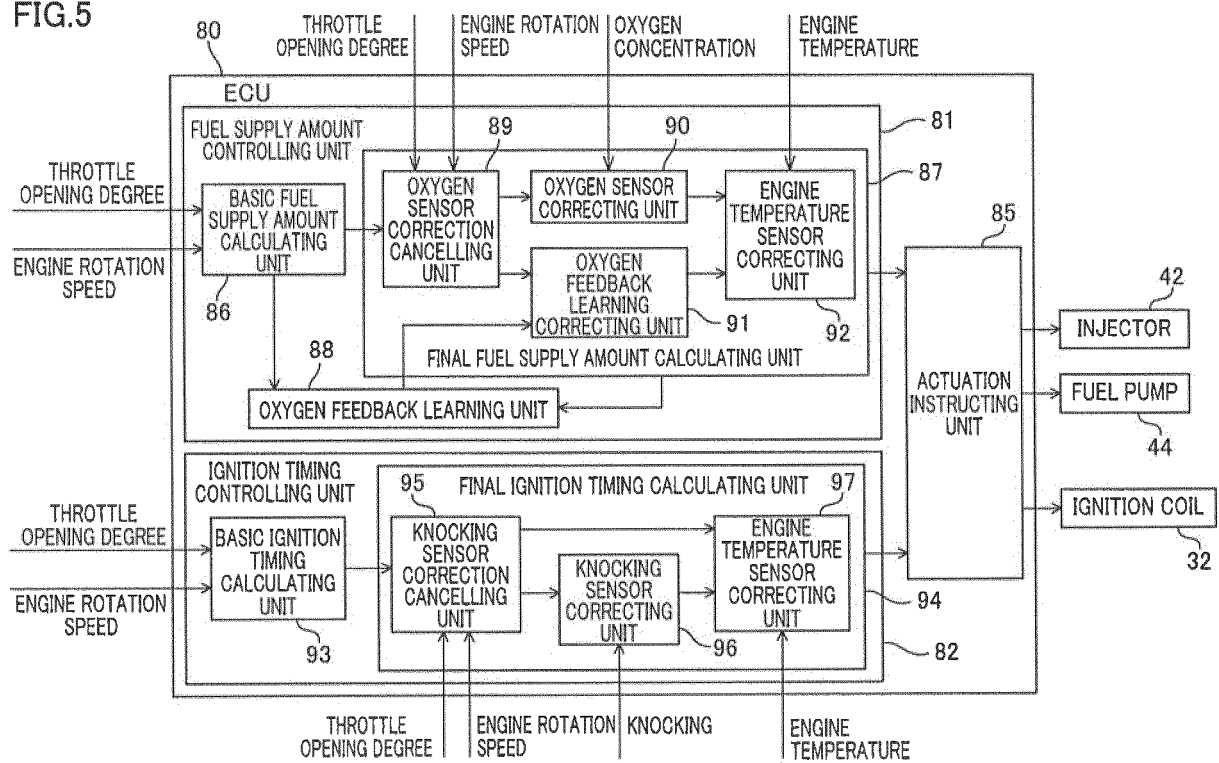


FIG.6

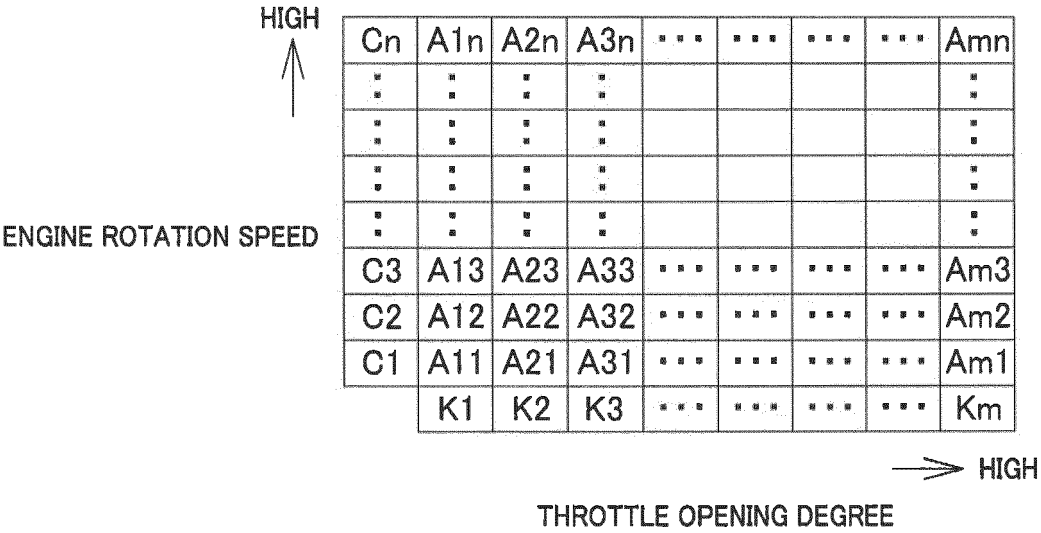


FIG.7

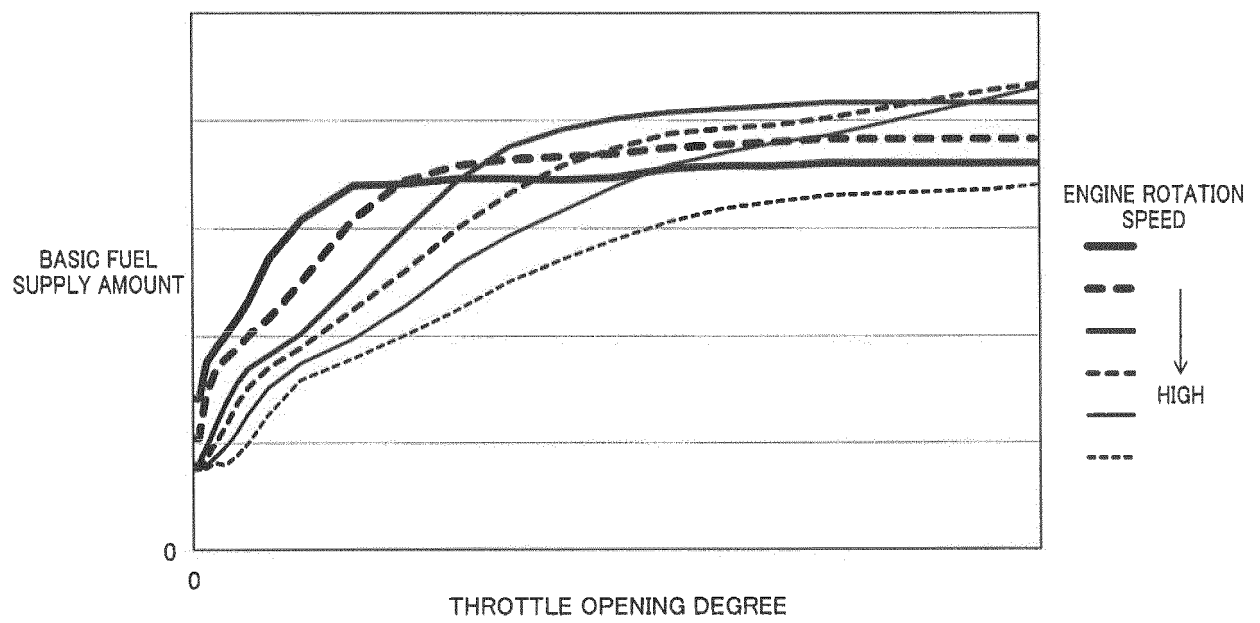


FIG.8

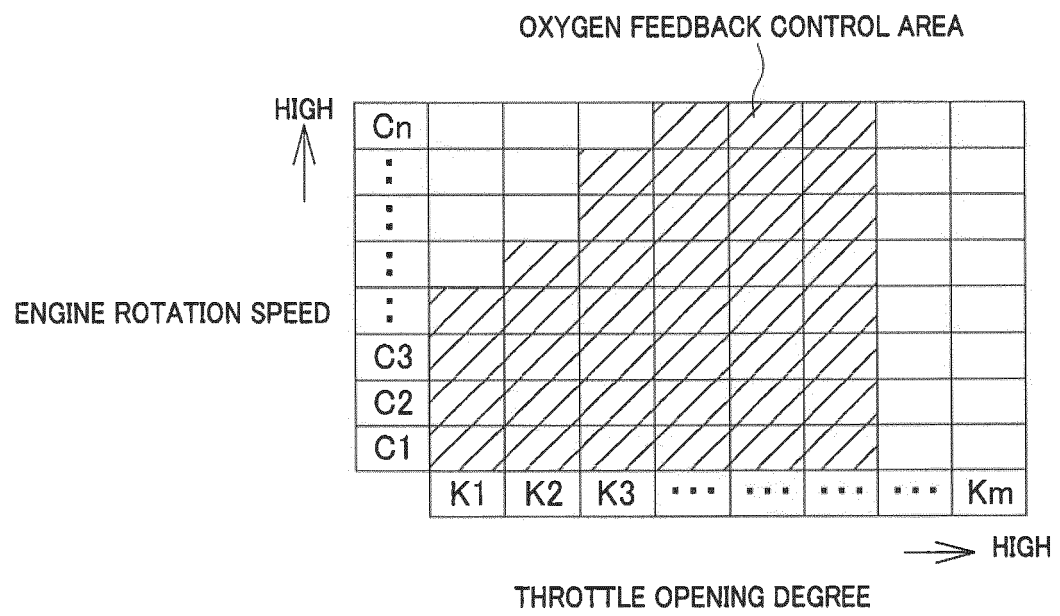


FIG.9

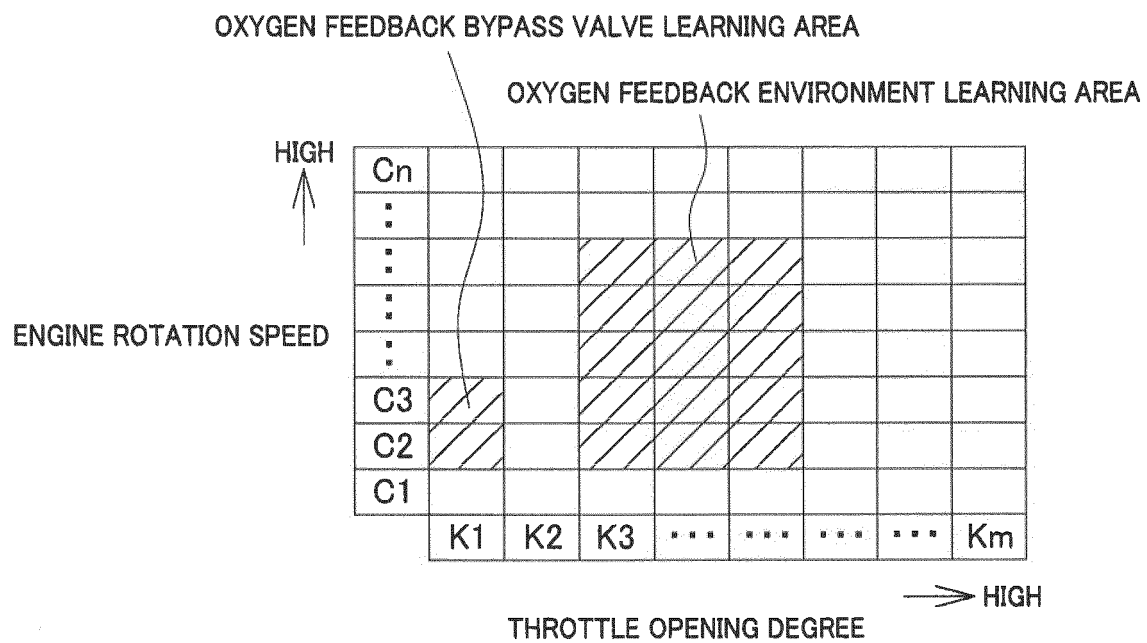


FIG.10

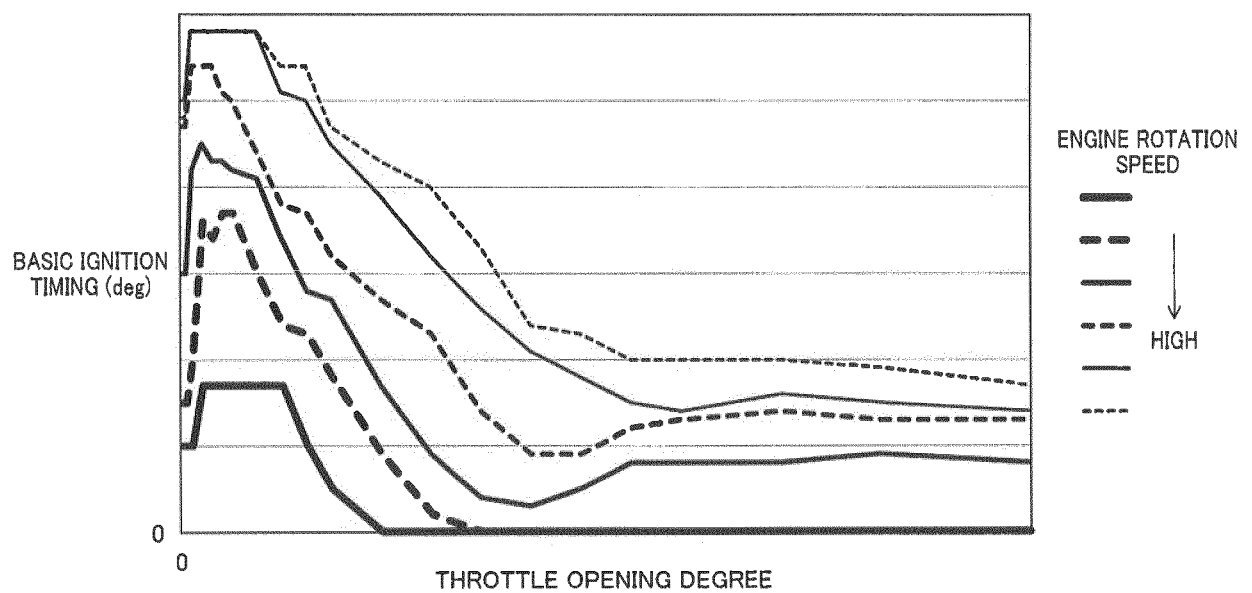
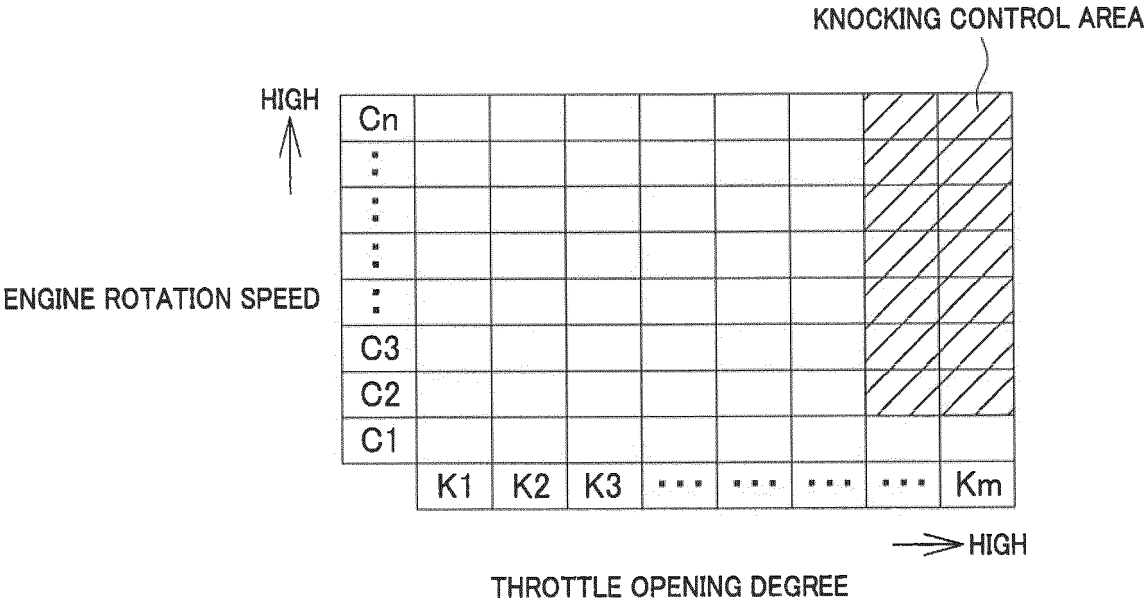


FIG.11



INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2015/084619

A. CLASSIFICATION OF SUBJECT MATTER

F02D45/00(2006.01)i, F02D29/02(2006.01)i, F02D17/00(2006.01)i, F02P5/152(2006.01)i, F02D41/14(2006.01)i, F02D9/10(2006.01)i, F02D43/00(2006.01)i, F01N3/20(2006.01)i, F01N3/28(2006.01)i

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

F02D41/00-45/00, F02D29/00-29/02, F02D17/00, F02P5/145-5/155, F02D9/10, F01N3/20, F01N3/28

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Jitsuyo Shinan Koho 1922-1996 Jitsuyo Shinan Toroku Koho 1996-2016
Kokai Jitsuyo Shinan Koho 1971-2016 Toroku Jitsuyo Shinan Koho 1994-2016

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	JP 2007-187004 A (Honda Motor Co., Ltd.), 26 July 2007 (26.07.2007), paragraphs [0011] to [0016]; fig. 1 to 2 & CN 101000003 A	1-6
Y	JP 2012-72718 A (Mitsubishi Electric Corp.), 12 April 2012 (12.04.2012), claims; paragraphs [0004], [0011], [0024] to [0026]; fig. 1 to 2 & US 2012/0073543 A1 claims; paragraphs [0006], [0015], [0042] to [0044]; fig. 1 to 2 & DE 102011083193 A1 & CN 102434351 A	1-6

☒ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

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Date of the actual completion of the international search
03 March 2016 (03.03.16)

Date of mailing of the international search report
15 March 2016 (15.03.16)

Name and mailing address of the ISA/
Japan Patent Office
3-4-3, Kasumigaseki, Chiyoda-ku,
Tokyo 100-8915, Japan

Authorized officer

Telephone No.

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INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2015/084619

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	JP 2013-83243 A (Honda Motor Co., Ltd.), 09 May 2013 (09.05.2013), claims; paragraphs [0019] to [0020] (Family: none)	2-6
Y	JP 2006-152806 A (Aisan Industry Co., Ltd.), 15 June 2006 (15.06.2006), claim 1; paragraphs [0011] to [0012], [0018] to [0019]; fig. 1 to 3 & CN 1782337 A	4-6
Y	JP 2003-74378 A (Keihin Corp.), 12 March 2003 (12.03.2003), paragraphs [0020], [0035]; fig. 2, 5, 10 to 11 (Family: none)	5-6

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REFERENCES CITED IN THE DESCRIPTION

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- JP H10067372 B [0003]