



(12) **EUROPEAN PATENT APPLICATION**

(43) Date of publication:
26.09.2018 Bulletin 2018/39

(51) Int Cl.:
F01P 3/08 (2006.01)

(21) Application number: **18163371.0**

(22) Date of filing: **22.03.2018**

(84) Designated Contracting States:
AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO RS SE SI SK SM TR
Designated Extension States:
BA ME
Designated Validation States:
KH MA MD TN

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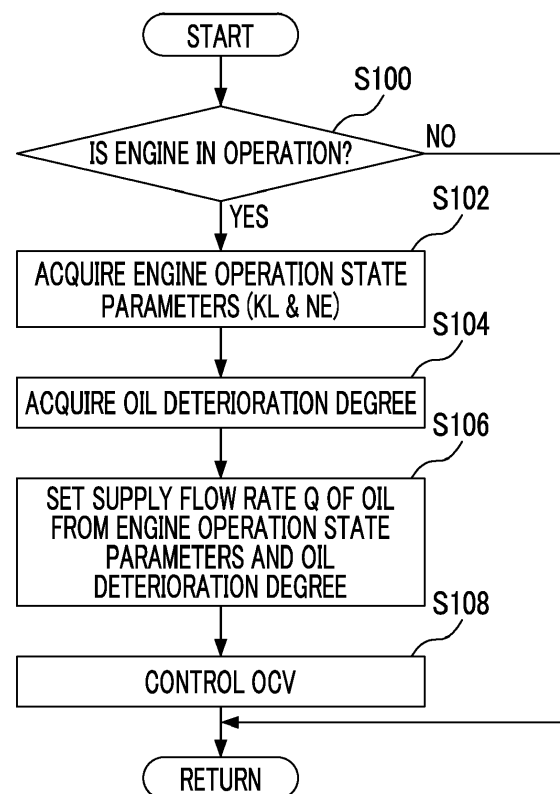
(30) Priority: **22.03.2017 JP 2017056391**

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(54) **CONTROL DEVICE AND CONTROL METHOD FOR INTERNAL COMBUSTION ENGINE**

(57) A control device for an internal combustion engine (10) including a piston (18), an oil jet (28) configured to inject oil toward the piston (18), and an actuator (34) configured to adjust a supply flow rate (Q) of the oil to the oil jet (28). The control device includes an electronic control unit (40) configured to control the actuator (34) such that the supply flow rate (Q) under the same engine load (KL) and the same engine rotation speed (NE) increases as a degree of deterioration of the oil increases.

FIG. 3



Description

BACKGROUND OF THE INVENTION

1. Field of the Invention

[0001] The invention relates to a control device and a control method for an internal combustion engine and, more particularly, to a control device and a control method for an internal combustion engine provided with an oil jet configured to inject oil toward a piston.

2. Description of Related Art

[0002] An oil jet device for an internal combustion engine provided with an oil jet configured to inject oil toward a piston is disclosed in, for example, Japanese Unexamined Patent Application Publication No. 2014-080888 (JP 2014-080888 A). Specifically, in the oil jet device, oil jet control is executed as follows when the engine is driven (when the engine is rotated by a wheel). In other words, in a situation in which the degree of deterioration of the oil does not exceed a predetermined value, the oil jet by the oil jet is stopped in a case where a predetermined oil jet stop condition is satisfied. In a situation in which the degree of deterioration of the oil exceeds the predetermined value, the oil jet by the oil jet is executed even in a case where the oil jet stop condition is satisfied.

SUMMARY OF THE INVENTION

[0003] There is a possibility that the insoluble component contained in the oil injected toward the piston by the oil jet accumulates on the piston as deposits once the piston reaches a high temperature. More specifically, the deposits are generated on the surface of the piston once the temperature of the piston exceeds a deposit generation temperature. The generation temperature falls as the oil deterioration degree increases. In other words, when the oil deterioration degree becomes high, the deposits are generated even in a condition in which the piston temperature is lower. However, the technique disclosed in JP 2014-080888 A pays no attention to controlling the oil jet in view of the fact that the deposit generation temperature falls as the oil deterioration degree increases. Therefore, the technique still has room for improvement in suppressing deposit generation from the oil injected toward the piston by the oil jet.

[0004] The invention provides a control device and a control method for an internal combustion engine allowing deposit generation to be effectively suppressed and a piston to be cooled at the same time regardless of the degree of deterioration of oil by allowing for the relationship between the oil deterioration degree and a deposit generation temperature.

[0005] A first aspect of the invention relates to a control device for an internal combustion engine. The internal combustion engine includes a piston, an oil jet configured

to inject oil toward the piston, and an actuator configured to adjust a supply flow rate of the oil to the oil jet. The control device includes an electronic control unit configured to control the actuator such that the supply flow rate under the same engine load and the same engine rotation speed increases as a degree of deterioration of the oil increases.

[0006] In the control device according to the first aspect of the invention, the electronic control unit may be configured to control the actuator such that the supply flow rate under the same engine load, the same engine rotation speed, and the same degree of deterioration of the oil increases as a temperature of the oil increases.

[0007] In the control device according to the first aspect of the invention, the electronic control unit may be configured to determine the supply flow rate such that the supply flow rate becomes the minimum amount needed for a temperature of the piston to be lower than a deposit generation temperature depending on the degree of deterioration of the oil.

[0008] A second aspect of the invention relates to a control method for an internal combustion engine. The internal combustion engine includes a piston, an oil jet configured to inject oil toward the piston, and an actuator configured to adjust a supply flow rate of the oil to the oil jet. The control method includes controlling, by the electronic control unit, the actuator such that the supply flow rate under the same engine load and the same engine rotation speed increases as a degree of deterioration of the oil increases.

[0009] The deposit generation temperature falls as the oil deterioration degree increases. According to the aspects of the invention, the actuator is controlled such that the supply flow rate of the oil to the oil jet increases as the oil deterioration degree increases under the same engine load and the same engine rotation speed. By allowing for the relationship between the oil deterioration degree and the deposit generation temperature as described above, deposit generation can be more effectively suppressed and the piston can be cooled at the same time regardless of the oil deterioration degree.

BRIEF DESCRIPTION OF THE DRAWINGS

[0010] Features, advantages, and technical and industrial significance of exemplary embodiments of the invention will be described below with reference to the accompanying drawings, in which like numerals denote like elements, and wherein:

FIG. 1 is a sectional view for showing a configuration of an internal combustion engine provided with an oil jet according to a first embodiment of the invention;

FIG. 2 is a graph showing the relationship of a supply flow rate Q of oil supplied by the oil jet to an oil deterioration degree and an engine load KL ;

FIG. 3 is a flowchart illustrating the routine of

processing relating to oil jet control according to the first embodiment of the invention;

FIG. 4 is a graph for showing the characteristics of a map that an ECU stores in the first embodiment in order to set the supply flow rate Q of the oil;

FIG. 5 is a flowchart illustrating the routine of processing relating to oil jet control according to a second embodiment of the invention;

FIG. 6 is a graph for showing the characteristics of a map that the ECU stores in the second embodiment in order to set the supply flow rate Q of the oil;

FIG. 7 is a flowchart illustrating the routine of processing relating to oil jet control according to a third embodiment of the invention;

FIG. 8 is a graph for showing the characteristics of a map that the ECU stores in the third embodiment in order to set the supply flow rate Q of the oil;

FIG. 9 is a flowchart illustrating the routine of processing relating to oil jet control according to a fourth embodiment of the invention; and

FIG. 10 is a graph for showing the characteristics of a map defining the relationship between engine operation state parameters and an increment ΔD in the oil deterioration degree.

DETAILED DESCRIPTION OF EMBODIMENTS

[0011] Hereinafter, embodiments of the invention will be described with reference to accompanying drawings. The invention is limited by the numbers mentioned to indicate the numbers, quantities, amounts, ranges, and so on of respective elements of the embodiments described below merely in a case where the limitation is particularly stated and merely in a case where the numbers clearly specify the numbers, quantities, amounts, ranges, and so on in principle. The structures, steps, and so on that are described in the embodiments described below are indispensable for the invention merely in a case where the indispensableness is particularly stated and merely in a case where the invention is clearly specified by the structures, steps, and so on in principle.

First Embodiment

[0012] A first embodiment of the invention will be described first with reference to FIGS. 1 to 4.

1. Configuration of Internal Combustion Engine According to First Embodiment

[0013] FIG. 1 is a sectional view for showing a configuration of an internal combustion engine 10 that is provided with an oil jet 28 according to the first embodiment of the invention. The internal combustion engine 10 is provided with a cylinder block 12 and a cylinder head 14. A plurality of cylinders 16 is formed in the cylinder block 12. One of the cylinders 16 is illustrated in FIG. 1. A piston 18 is disposed in each of the cylinders 16. The piston 18

is configured to reciprocate in the cylinder 16.

1-1. Lubrication System for Internal Combustion Engine

[0014] An oil pan 20 for keeping oil lubricating each portion of the internal combustion engine 10 is attached to the lower end portion of the cylinder block 12. The oil in the oil pan 20 is pumped up by an oil pump 24 via an oil strainer 22. After the oil is pumped up, the oil is sent to a main gallery 26 formed in the cylinder block 12 and distributed from the main gallery 26 to each portion of the internal combustion engine 10.

[0015] In the internal combustion engine 10, some of the oil supplied to the main gallery 26 can be supplied to the oil jet 28 as described below. The oil jet 28 is configured to be capable of injecting the oil toward the piston 18 (back surface of the piston 18 to be more specific). Cooling of the piston 18 can be performed by the oil being supplied to the piston 18 by the oil jet 28.

1-2. Oil Jet

[0016] The oil jet 28 is provided with a plurality of injection nozzles 30 and an oil jet gallery 32. The injection nozzle 30 is installed in each cylinder. The oil jet gallery 32 is a flow path for distributing the oil supplied from the main gallery 26 to each of the injection nozzles 30.

1-3. Actuator Controlling Supply Flow Rate of Oil

[0017] The internal combustion engine 10 is provided with an oil control valve (OCV) 34 as an example of an actuator adjusting the supply flow rate of the oil to the oil jet 28. More specifically, the OCV 34 is disposed to control the flow rate of the oil supplied from the main gallery 26 to the oil jet gallery 32. The OCV 34 is, for example, electromagnetic and opened and closed based on a command from an ECU 40 (described later).

[0018] Once the OCV 34 is opened, some of the oil in the main gallery 26 is supplied to each injection nozzle 30 via the oil jet gallery 32. As a result, the oil is injected from each injection nozzle 30 toward the piston 18 of each cylinder 16. When the OCV 34 is closed, oil supply from the main gallery 26 to the oil jet gallery 32 is stopped. As a result, oil injection from each injection nozzle 30 is also stopped. Accordingly, the supply flow rate of the oil to the piston 18 can be controlled by the ECU 40 controlling the valve opening time of the OCV 34.

1-4. Control System for Internal Combustion Engine

[0019] The system that is illustrated in FIG. 1 is provided with the ECU 40 as a control device. Various sensors mounted in an internal combustion engine and a vehicle in which the internal combustion engine is mounted are electrically connected to the ECU 40. The various sensors include a crank angle sensor 42, an air flow sensor 44, an oil temperature sensor 46, and an oil deterior-

ration sensor 48. The crank angle sensor 42 outputs a signal depending on a crank angle. The ECU 40 is capable of acquiring an engine rotation speed NE by using the crank angle sensor 42. The air flow sensor 44 outputs a signal depending on the flow rate of air suctioned into an internal combustion engine. The oil temperature sensor 46 outputs a signal depending on the temperature of the oil. The oil deterioration sensor 48 is, for example, a sensor that outputs a signal depending on the dielectric constant of oil. The ECU 40 stores the dielectric constant of new oil and determines a current oil deterioration degree by comparing the dielectric constant of the new oil to a current oil dielectric constant acquired by the oil deterioration sensor 48 being used. The oil deterioration degree determination method using the oil deterioration sensor is not limited to the method described above.

[0020] Various actuators such as a fuel injection valve are electrically connected to the ECU 40 along with the OCV 34 so that the operation of the internal combustion engine is controlled.

2. Oil Jet Control According to First Embodiment

[0021] The engine control that is performed by the ECU 40 includes oil jet control based on control of the OCV 34.

2-1. Generation of Deposits from Oil on Surface of Piston

[0022] An insoluble component (such as oil sludge) is contained in the oil present around a cylinder in which combustion is performed and exposed to a high temperature. There is a possibility that the insoluble component contained in the oil injected toward a piston by an oil jet accumulates on the piston as deposits once the piston reaches a high temperature. More specifically, the deposits are generated on the surface of the piston once the temperature of the piston exceeds a deposit generation temperature. Once the deposits are generated on the surface of the piston, cooling of the piston by the oil is hindered.

2-2. Control of Supply Flow Rate of Oil Allowing for Oil Deterioration Degree

[0023] The deposit generation temperature falls as the oil deterioration degree increases. In other words, when the oil deterioration degree becomes high, the deposits are generated even in a condition in which the piston temperature is lower. In this regard, in the first embodiment, the following oil supply flow rate control is executed in view of the relationship between the oil deterioration degree and the deposit generation temperature so that deposit generation can be more effectively suppressed and the piston 18 can be cooled at the same time.

[0024] FIG. 2 is a graph showing the relationship of a supply flow rate Q of the oil supplied by the oil jet 28 to the oil deterioration degree and an engine load KL. The oblique lines in FIG. 2 respectively represent the contours

of values Q1 to Q8 of the oil supply flow rate. The value of the oil supply flow rate is large in the order of Q1, Q2, Q3, ... Q7, Q8. More specifically, the supply flow rate Q corresponds to the amount of the oil injected from the individual injection nozzles 30.

[0025] According to the relationship that is illustrated in FIG. 2, the supply flow rate Q of the oil increases as the oil deterioration degree increases under the same engine load KL. Under the same oil deterioration degree, the supply flow rate Q of the oil increases as the engine load KL (engine load factor to be more specific) increases. The individual values Q1 and the like of the supply flow rate Q are determined such that the temperature of the piston 18 can be lower than the deposit generation temperature under the engine load KL and the oil deterioration degree associated with the values.

[0026] In the first embodiment, the oil deterioration degree is determined by the oil deterioration sensor 48 being used during the operation of the internal combustion engine 10. Then, the supply flow rate Q, which is the amount of the oil that should be injected from each injection nozzle 30, is determined in accordance with the relationship illustrated in FIG. 2 and in accordance with the oil deterioration degree and the engine load KL. In the first embodiment, the ECU 40 controls the supply flow rate of the oil to the piston 18 by controlling the valve opening time of the OCV 34. However, the supply flow rate of the oil may also be controlled by a variable oil pump or an electric oil pump being used instead of the OCV 34.

2-3. Example of Processing by ECU

[0027] FIG. 3 is a flowchart illustrating the routine of processing relating to the oil jet control according to the first embodiment of the invention. The routine illustrated in FIG. 3 is repeatedly executed at a predetermined control cycle.

[0028] In the routine illustrated in FIG. 3, the ECU 40 first determines whether or not the engine is in operation (Step S100). The engine being in operation means a state where the generation of engine torque for vehicle traveling by the internal combustion engine 10 is underway. In a case where the ECU 40 determines in Step S100 that the engine is not in operation, the ECU 40 terminates the processing at a time when the current routine is started.

[0029] In a case where the ECU 40 determines in Step S100 that the engine is in operation, the ECU 40 acquires the engine load KL and the engine rotation speed NE as engine operation state parameters (Step S102). The engine load KL can be calculated based on, for example, the intake air amount acquired by the air flow sensor 44 being used and the engine rotation speed NE based on the crank angle sensor 42.

[0030] The ECU 40 acquires the current oil deterioration degree by using the oil deterioration sensor 48 (Step S104).

[0031] The ECU 40 sets the supply flow rate Q of the oil based on the acquired engine operation state parameters and oil deterioration degree (Step S106). Specifically, the supply flow rate Q is set by the map that will be described below with reference to FIG. 4 being used.

[0032] FIG. 4 is a graph for showing the characteristics of the map that the ECU 40 stores in the first embodiment in order to set the supply flow rate Q of the oil. The vertical axis of FIG. 4 may also be, for example, the engine torque as an engine operation state parameter relating to the engine load KL instead of the engine load KL . This also applies to the characteristics of the maps that are illustrated in FIGS. 6, 8, and 10 (described later).

[0033] The characteristics of the map illustrated in FIG. 4 are determined based on the same idea as the relationship illustrated in FIG. 2 described above and in view of the oil deterioration degree and the engine load KL . In addition, in the example illustrated in FIG. 4, the supply flow rate Q is determined in view of the engine rotation speed NE as well. Each map value of the supply flow rate Q on the map is determined such that the temperature of the piston 18 can be lower than the deposit generation temperature.

[0034] Specifically, according to the map, the supply flow rate Q is determined such that the supply flow rate Q increases as the oil deterioration degree increases under the same engine load KL and the same engine rotation speed NE as illustrated in FIG. 4. Under the same oil deterioration degree, the supply flow rate Q is determined such that the supply flow rate Q increases as the engine load KL increases and, likewise, the supply flow rate Q increases as the engine rotation speed NE increases.

[0035] Furthermore, the graph 4-1 that is exemplified on the lower side of FIG. 4 represents the characteristics of a map for new oil (that is, oil with a relatively low oil deterioration degree) and the graph 4-2 that is exemplified on the upper side of FIG. 4 represents the characteristics of a map for deteriorated oil (that is, oil with a relatively high oil deterioration degree). As is apparent from the examples described above, when the oil deterioration degree is relatively high, each map value is determined such that the rate of increase (slope of increase) in the supply flow rate Q with respect to an increase in the engine load KL and an increase in the engine rotation speed NE is higher than when the oil deterioration degree is relatively low.

[0036] The ECU 40 controls the OCV 34 for the set supply flow rate Q of the oil to be obtained (Step S108).

2-4. Effect of Oil Jet Control According to First Embodiment

[0037] As described above, the deposit generation temperature falls as the oil deterioration degree increases. In this regard, according to the processing of the routine that is illustrated in FIG. 3, the supply flow rate Q is increased as the oil deterioration degree increases under

the same engine load KL and the same engine rotation speed NE . In other words, according to the processing described above, cooling of the piston 18 is further promoted by an oil amount increase as oil deterioration proceeds in view of the fact that the deposit generation temperature falls as the oil deterioration degree increases. Accordingly, the generation of the deposits from the oil on the surface of the piston 18 can be suppressed regardless of the oil deterioration degree. As a result, the oil-based cooling of the piston 18 can be made unlikely to be hindered by deposit generation on the surface of the piston 18. Therefore, the reliability of the cooling of the piston 18 by the oil jet 28 can be improved.

[0038] More specifically, according to the processing above in which the supply flow rate Q is increased as the oil deterioration degree increases, oil supply entailing a minimum increase in amount needed for the piston cooling can be easily realized under the individual oil deterioration degrees (deterioration progress states) compared to an example in which the supply flow rate Q is increased with room at once when, for example, the oil deterioration degree exceeds a predetermined value. In this regard, in the first embodiment, the supply flow rate Q corresponding to the individual oil deterioration degree is determined, as an example of a preferred method for setting the supply flow rate Q in accordance with the oil deterioration degree, such that the supply flow rate Q becomes the minimum amount needed for the temperature of the piston 18 to fall below the deposit generation temperature depending on the oil deterioration degree. Therefore, deposit generation can be reliably suppressed under the individual oil deterioration degree by the minimum needed increase in the amount of the oil.

[0039] Moreover, the increase in the amount of the oil becoming capable of being the minimum amount needed for the piston cooling leads to fuel economy improvement by causing the friction and cooling loss of the internal combustion engine 10 to be reduced. The viscosity of the oil tends to decline when the oil deteriorates. Accordingly, it can be said that a decline in fuel economy attributable to an increase in oil amount does not occur even when the supply flow rate Q of the oil for piston cooling is increased with the deterioration as described above.

[0040] According to the processing of the routine described above, the supply flow rate Q is determined in accordance with engine operation states. In other words, under the same oil deterioration degree, the supply flow rate Q is increased as the engine load KL increases and the engine rotation speed NE increases. When the engine load KL becomes high, the amount of heat that the piston 18 receives from one combustion increases, and thus the temperature of the piston 18 becomes likely to rise. When the engine rotation speed NE becomes high, the amount of heat that the piston 18 receives from combustion gas per unit time increases, and thus the temperature of the piston 18 becomes likely to rise. Therefore, according to the processing above, the supply flow rate Q can be determined such that the supply flow rate

Q becomes an appropriate amount needed for the piston cooling under the individual engine operation states (herein, the engine load KL and the engine rotation speed NE).

Second Embodiment

[0041] A second embodiment of the invention will be described with reference to FIGS. 5 and 6. In the following description, the configuration that is illustrated in FIG. 1 is used as an example of the system configuration of the second embodiment.

1. Oil Jet Control According to Second Embodiment

[0042] The oil jet control according to the second embodiment differs from the oil jet control according to the first embodiment in that the temperature of the oil is added to the engine operation state parameters used along with the oil deterioration degree for the determination of the supply flow rate Q of the oil.

1-1. Example of Processing by ECU

[0043] FIG. 5 is a flowchart illustrating the routine of processing relating to the oil jet control according to the second embodiment of the invention. The processing of Steps S100, S104, and S108 in the routine illustrated in FIG. 5 is as described above in the first embodiment.

[0044] In the routine illustrated in FIG. 5, the ECU 40 acquires the engine load KL, the engine rotation speed NE, and the temperature of the oil as engine operation state parameters (Step S200) in a case where the ECU 40 determines in Step S100 that the engine is in operation. The temperature of the oil is acquired by, for example, the oil temperature sensor 46 being used.

[0045] In the routine illustrated in FIG. 5, the ECU 40 sets the supply flow rate Q of the oil (Step S202) based on the oil deterioration degree and the acquired engine operation state parameters (including the temperature of the oil) after the processing of Step S104. Specifically, the supply flow rate Q is set by the map that will be described below with reference to FIG. 6 being used.

[0046] FIG. 6 is a graph for showing the characteristics of the map that the ECU 40 stores in the second embodiment in order to set the supply flow rate Q of the oil. Added to the characteristics of the map illustrated in FIG. 6 compared to the characteristics of the map illustrated in FIG. 4 is the setting of the supply flow rate Q based on the viewpoint of the temperature of the oil as well as the viewpoint of the engine load KL, the engine rotation speed NE, and the oil deterioration degree.

[0047] Specifically, according to the map, the supply flow rate Q is determined such that the supply flow rate Q increases as the temperature of the oil increases under the same engine load KL, the same engine rotation speed NE, and the same oil deterioration degree. The graph 6-1 that is exemplified in the lower part of FIG. 6 repre-

sents the characteristics of a map for oil (new oil) with a relatively low oil deterioration degree and a relatively low temperature, and the graph 6-2 that is exemplified in the middle part of FIG. 6 represents the characteristics of a map for oil (deteriorated oil) with a relatively high oil deterioration degree and a relatively low temperature. The graph 6-3 that is exemplified in the upper part of FIG. 6 represents the characteristics of a map for oil (deteriorated oil) with a relatively high oil deterioration degree and a relatively high temperature.

[0048] As is apparent from the examples illustrated in FIG. 6, when the oil deterioration degree is relatively high, each map value is determined such that the rate of increase (slope of increase) in the supply flow rate Q with respect to an increase in the engine load KL and an increase in the engine rotation speed NE is higher than when the oil deterioration degree is relatively low. In addition, when the temperature of the oil as well as the oil deterioration degree is relatively high, each map value is determined such that the rate of increase (slope of increase) in the supply flow rate Q with respect to an increase in the engine load KL and an increase in the engine rotation speed NE is even higher with a rise in the temperature of the oil.

1-2. Effect of Oil Jet Control According to Second Embodiment

[0049] The setting of the supply flow rate Q based on the viewpoint of the temperature of the oil is added to the above-described routine illustrated in FIG. 5 compared to the oil jet control according to the first embodiment. When the temperature of the oil is relatively high, the temperature of the piston 18 becomes unlikely to be lowered with the same oil amount. According to the processing of the routine described above, the supply flow rate Q is increased as the temperature of the oil increases under the same engine load KL, the same engine rotation speed NE, and the same oil deterioration degree. As a result, cooling of the piston 18 is further promoted by an oil amount increase as the temperature of the oil increases. Accordingly, the supply flow rate Q can be determined such that the supply flow rate Q becomes an appropriate amount needed for the piston cooling with a change in the temperature of the oil also taken into account.

Third Embodiment

[0050] A third embodiment of the invention will be described with reference to FIGS. 7 and 8. In the following description, the configuration that omits the oil deterioration sensor 48 from the configuration illustrated in FIG. 1 is used as an example of the system configuration of the third embodiment. This also applies to a fourth embodiment (described later).

1. Oil Jet Control According to Third Embodiment

[0051] The oil jet control according to the third embodiment differs from the oil jet control according to the first embodiment merely in terms of the oil deterioration degree determination method. Specifically, in the third embodiment, the oil deterioration degree is determined based on engine operation time instead of the use of the oil deterioration sensor 48.

1-1. Example of Processing by ECU

[0052] FIG. 7 is a flowchart illustrating the routine of processing relating to the oil jet control according to the third embodiment of the invention. The processing of Steps S100, S102, and S108 in the routine illustrated in FIG. 7 is as described above in the first embodiment.

[0053] In the routine illustrated in FIG. 7, the ECU 40 first determines the execution or non-execution of oil exchange (Step S300). The execution or non-execution of the oil exchange can be determined based on, for example, the presence or absence of a history of operation of an oil exchange switch (not illustrated) manually operated when the oil exchange is completed. Alternatively, the execution or non-execution of the oil exchange may also be determined based on, for example, the presence or absence of a detection history regarding a decrease in oil level to or below a predetermined level by an oil level sensor (not illustrated) being used.

[0054] In a case where the ECU 40 determines in Step S300 that the oil exchange has been executed, the ECU 40 resets engine operation time T to zero (Step S302). In a case where the ECU 40 determines that the oil exchange is yet to be executed, the ECU 40 determines in Step S100 whether or not the engine is in operation.

[0055] In a case where the engine is in operation as a result, the ECU 40 acquires the engine operation state parameters in Step S102. The ECU 40 counts up the engine operation time T (Step S304). According to the processing described above, the engine operation time T from the time when the oil exchange is executed can be grasped. Oil deterioration proceeds as the engine operation time T lengthens. Accordingly, the ECU 40 is capable of determining that the oil deterioration degree increases as the engine operation time T lengthens.

[0056] The ECU 40 sets the supply flow rate Q of the oil based on the oil deterioration degree based on the engine operation time T and the acquired engine operation state parameters (Step S306). Specifically, the supply flow rate Q is set by the map that will be described below with reference to FIG. 8 being used.

[0057] FIG. 8 is a graph for showing the characteristics of the map that the ECU 40 stores in the third embodiment in order to set the supply flow rate Q of the oil. The characteristics of the map illustrated in FIG. 8 are identical to the characteristics of the map illustrated in FIG. 4 except that the engine operation time T is used instead of the calculated value based on the output of the oil deterioro-

ration sensor 48 as the index value of the oil deterioration degree.

1-2. Effect of Oil Jet Control According to Third Embodiment

[0058] According to the processing of the routine illustrated in FIG. 7 described above, the supply flow rate Q of the oil is controlled in view of the oil deterioration degree by an existing sensor being used in a vehicle with the oil deterioration sensor 48 not provided.

2. Modification Example

[0059] In the third embodiment described above, an example has been described in which the oil deterioration degree is determined based on the engine operation time T from the point in time when the oil exchange is executed. However, the determination of the oil deterioration degree may also be based on, for example, the traveling distance of the vehicle from the point in time when the oil exchange is executed instead of the engine operation time T described above. Specifically, the ECU 40 may determine that the oil deterioration degree increases as the traveling distance from the point in time when the oil exchange is executed increases. The traveling distance can be acquired by, for example, the trip meter (not illustrated) of the vehicle being used.

[0060] The setting of the supply flow rate Q based on the viewpoint of the temperature of the oil described in the second embodiment may also be combined with the oil jet control using the oil deterioration degree determination method based on the above-described traveling distance or the engine operation time T according to the third embodiment described above.

Fourth Embodiment

[0061] The fourth embodiment of the invention will be described with reference to FIGS. 9 and 10.

1. Oil Jet Control According to Fourth Embodiment

[0062] The oil jet control according to the fourth embodiment differs from the oil jet control according to the first embodiment merely in terms of the oil deterioration degree determination method. In the fourth embodiment, the oil deterioration degree is determined based on an oil deterioration degree index value D calculated from the engine operation state parameters instead of the use of the oil deterioration sensor 48.

1-1. Example of Processing by ECU

[0063] FIG. 9 is a flowchart illustrating the routine of processing relating to the oil jet control according to the fourth embodiment of the invention. The processing of Steps S100, S108, S200, and S300 in the routine illus-

trated in FIG. 9 is as described above in the first to third embodiments.

[0064] In the routine illustrated in FIG. 9, the ECU 40 resets the oil deterioration degree index value D to zero (Step S400) in a case where the ECU 40 determines in Step S300 that the oil exchange has been executed. In a case where the ECU 40 determines that the oil exchange is yet to be executed, the ECU 40 determines in Step S100 whether or not the engine is in operation.

[0065] In a case where the engine is in operation as a result, the ECU 40 acquires the engine operation state parameters in Step S200. The ECU 40 updates the oil deterioration degree index value D by adding an increment ΔD in the oil deterioration degree to the previous value of the oil deterioration degree index value D (Step S402).

[0066] Specifically, the increment ΔD in the oil deterioration degree is calculated by, for example, the map that will be described below with reference to FIG. 10 being used. FIG. 10 is a graph for showing the characteristics of a map defining the relationship between the engine operation state parameters and the increment ΔD in the oil deterioration degree. The oil is likely to deteriorate as the temperature of the oil increases. Accordingly, in the map, the increment ΔD is determined such that the increment ΔD increases as the temperature of the oil (oil temperature) increases under the same engine load KL and the same engine rotation speed NE as illustrated in FIG. 10. Under the same temperature of the oil, the increment ΔD is determined such that the increment ΔD increases as the engine load KL increases and, likewise, the increment ΔD increases as the engine rotation speed NE increases.

[0067] Furthermore, the graph 10-1 that is exemplified on the lower side of FIG. 10 represents the characteristics of a map for oil with a relatively low temperature and the graph 10-2 that is exemplified on the upper side of FIG. 10 represents the characteristics of a map for oil with a relatively high temperature. As is apparent from the examples described above, when the temperature of the oil is relatively high, each map value is determined such that the rate of increase in the increment ΔD with respect to an increase in the engine load KL and an increase in the engine rotation speed NE is higher than when the temperature of the oil is relatively low.

[0068] In the fourth embodiment, an example in which the engine operation state parameters used for the calculation of the increment ΔD include the engine rotation speed NE along with the engine load KL and the engine rotation speed NE has been described with reference to FIG. 10. However, the engine operation state parameters used for the calculation of the increment ΔD may, for example, consist of the engine load KL and the temperature of the oil without including the engine rotation speed NE or the engine operation state parameters may consist of the engine load KL alone.

[0069] In Step S402, the ECU 40 calculates the increment ΔD in accordance with the current engine load KL,

engine rotation speed NE, and temperature of the oil by referring to the map described above and calculates the current value of the oil deterioration degree index value D by using the calculated increment ΔD . With the oil deterioration degree index value D calculated (updated) as described above, the ECU 40 is capable of determining that the oil deterioration degree relatively increases as the oil deterioration degree index value D increases.

[0070] The ECU 40 sets the supply flow rate Q of the oil based on the oil deterioration degree based on the deterioration degree index value D and the acquired engine operation state parameters (Step S404). The map that is used for the setting of the supply flow rate Q in the processing of Step S404 is identical except that the oil deterioration degree index value D is used instead of the engine operation time T in FIG. 8, and thus detailed description thereof will be omitted herein.

1-2. Effect of Oil Jet Control According to Fourth Embodiment

[0071] The processing of the routine illustrated in FIG. 9 described above also allows the supply flow rate Q of the oil to be controlled in view of the oil deterioration degree by an existing sensor being used in a vehicle with the oil deterioration sensor 48 not provided.

2. Modification Example

[0072] The setting of the supply flow rate Q based on the temperature of the oil described in the second embodiment may also be combined with the oil jet control using the oil deterioration degree determination method according to the above-described fourth embodiment based on the oil deterioration degree index value D.

Claims

1. A control device for an internal combustion engine (10) including a piston (18), an oil jet (28) configured to inject oil toward the piston (18), and an actuator (34) configured to adjust a supply flow rate (Q) of the oil to the oil jet (28), the control device comprising an electronic control unit (40) configured to control the actuator (34) such that the supply flow rate (Q) under the same engine load (KL) and the same engine rotation speed (NE) increases as a degree of deterioration of the oil increases.
2. The control device according to claim 1, wherein the electronic control unit (40) is configured to control the actuator (34) such that the supply flow rate (Q) under the same engine load (KL), the same engine rotation speed (NE), and the same degree of deterioration of the oil increases as a temperature of the oil increases.

3. The control device according to claim 1 or 2, wherein the electronic control unit (40) is configured to determine the supply flow rate (Q) such that the supply flow rate (Q) becomes a minimum amount needed for a temperature of the piston (18) to be lower than a deposit generation temperature depending on the degree of deterioration of the oil. 5
4. A control method for an internal combustion engine (10) including a piston (18), an oil jet (28) configured to inject oil toward the piston (18), and an actuator (34) configured to adjust a supply flow rate (Q) of the oil to the oil jet (28), the control method comprising controlling, by the electronic control unit (40), the actuator (34) such that the supply flow rate (Q) under the same engine load (KL) and the same engine rotation speed (NE) increases as a degree of deterioration of the oil increases. 10 15

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FIG. 1

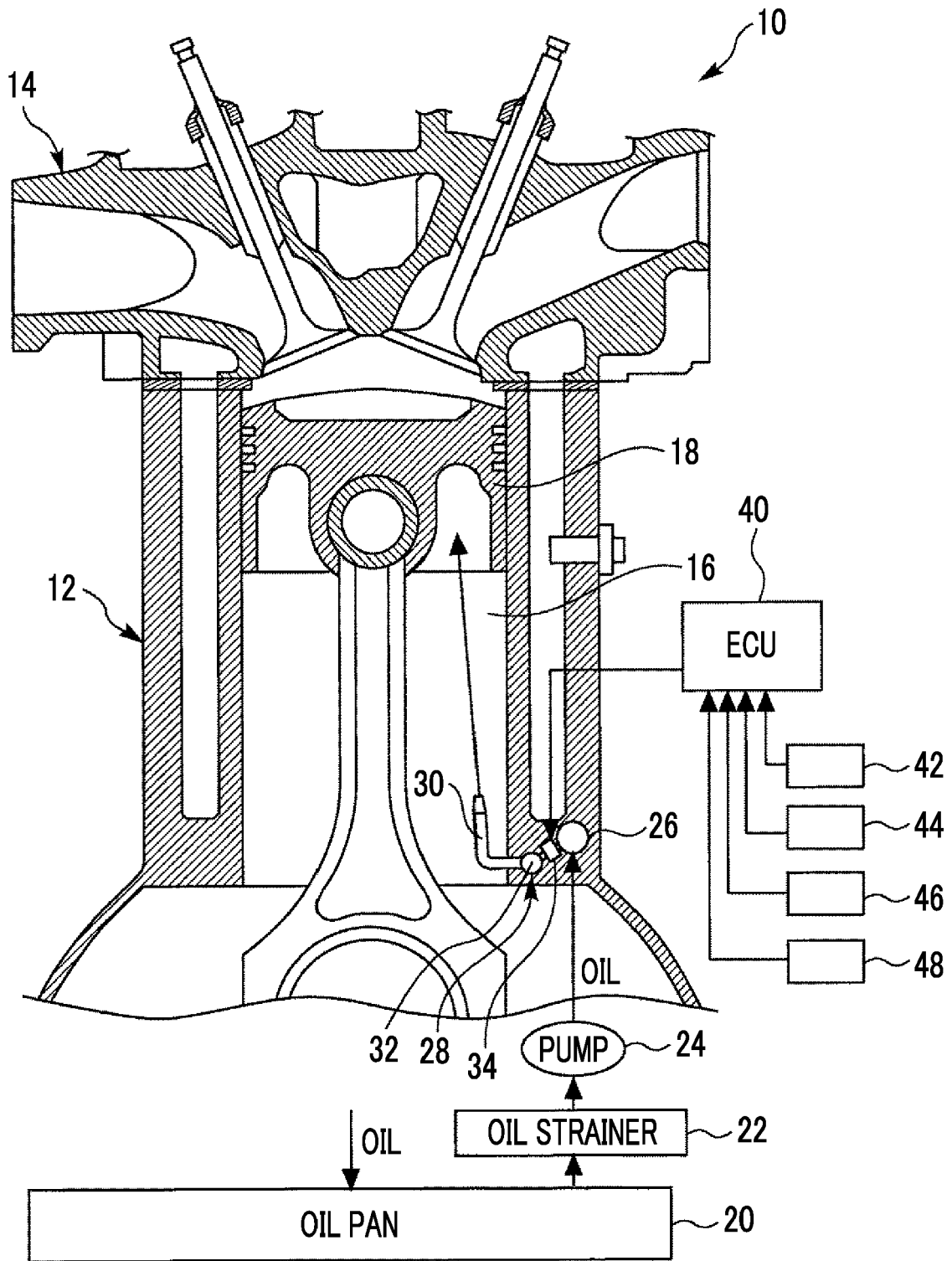


FIG. 2

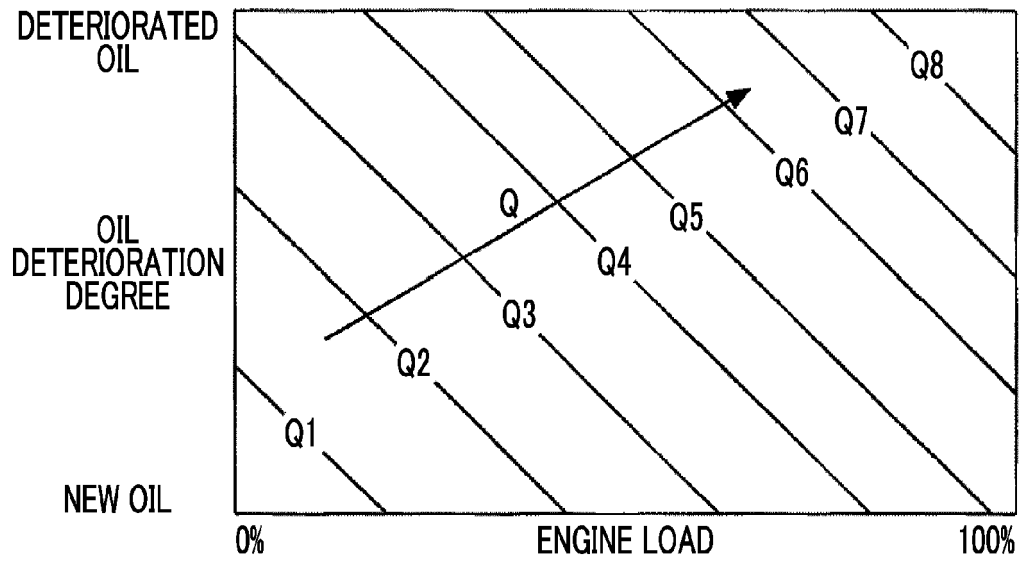


FIG. 3

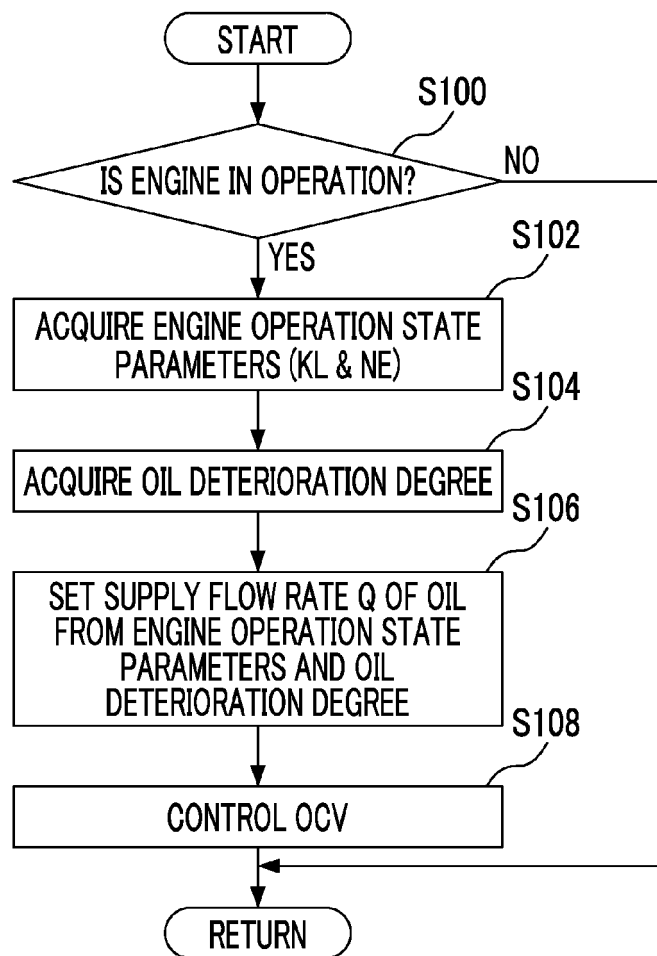


FIG. 4

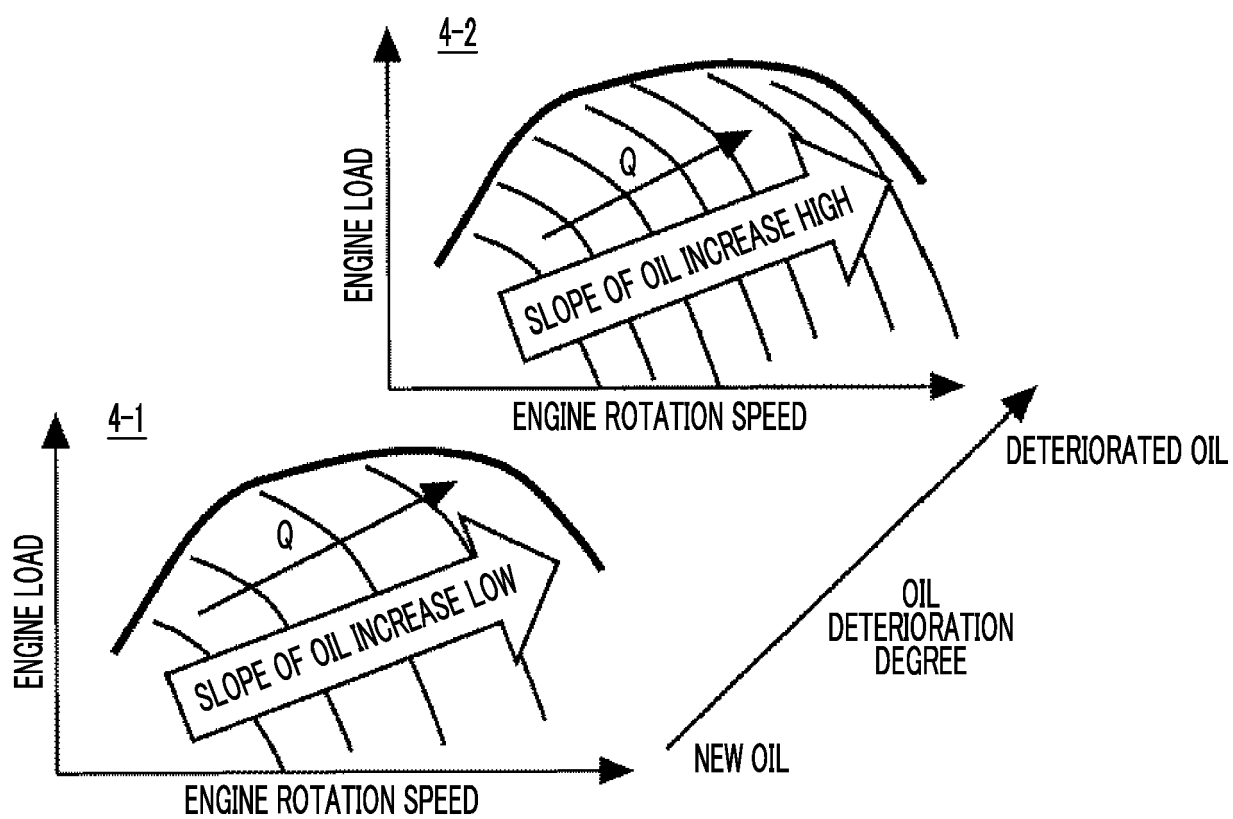


FIG. 5

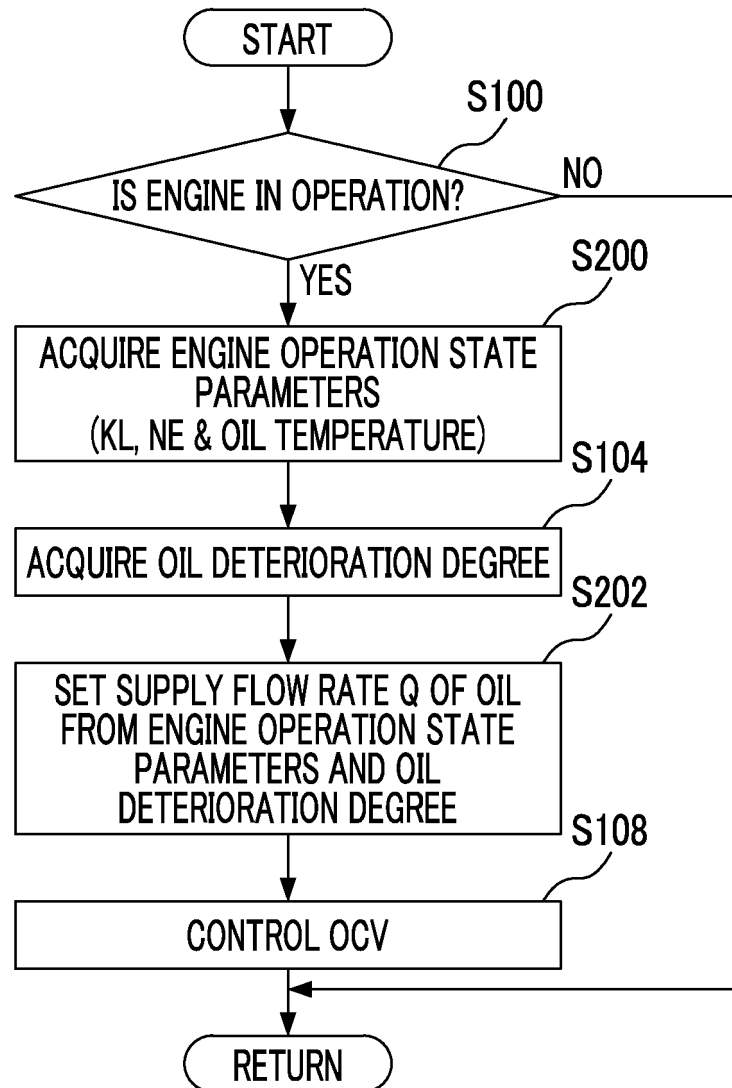


FIG. 6

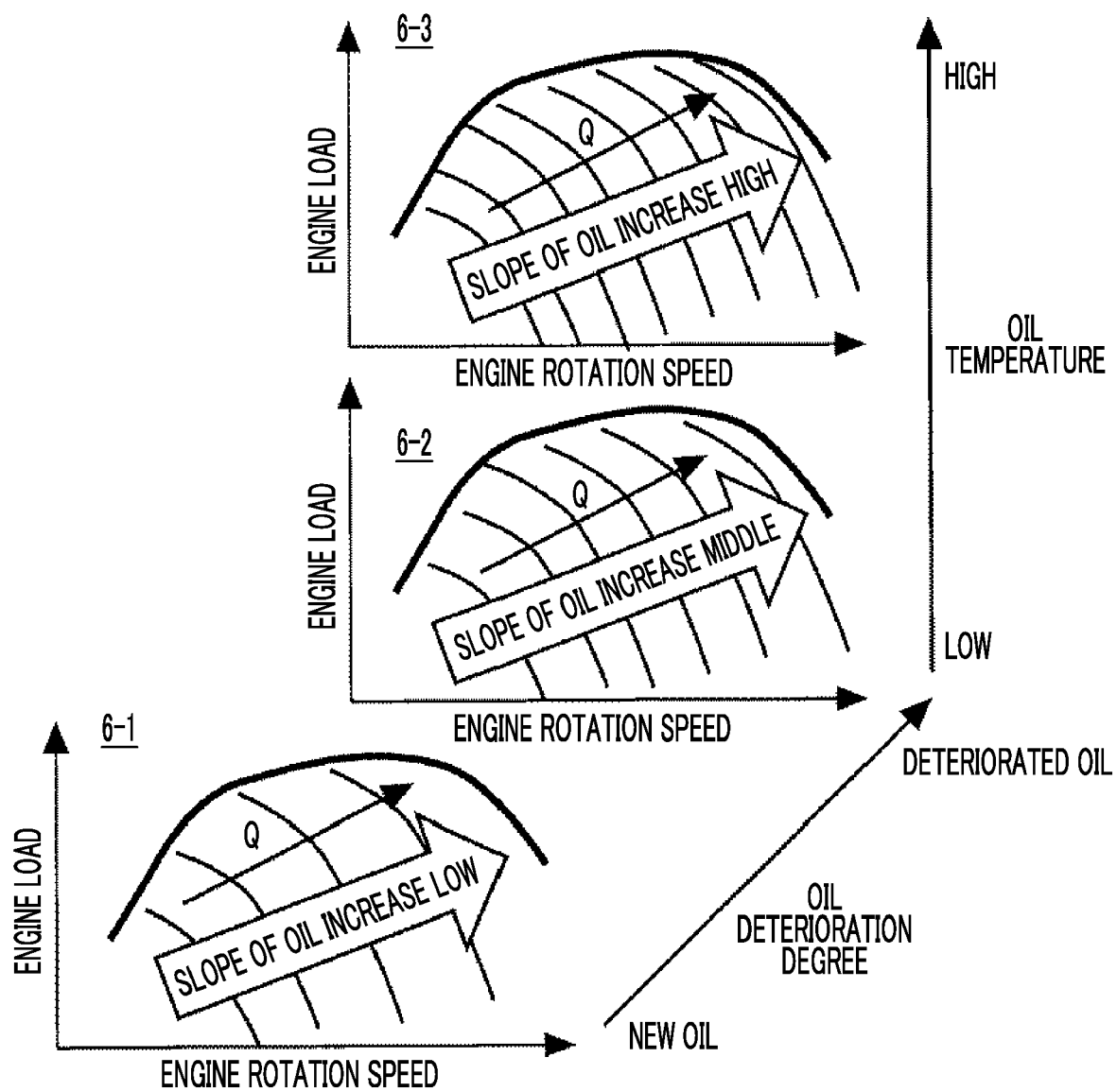


FIG. 7

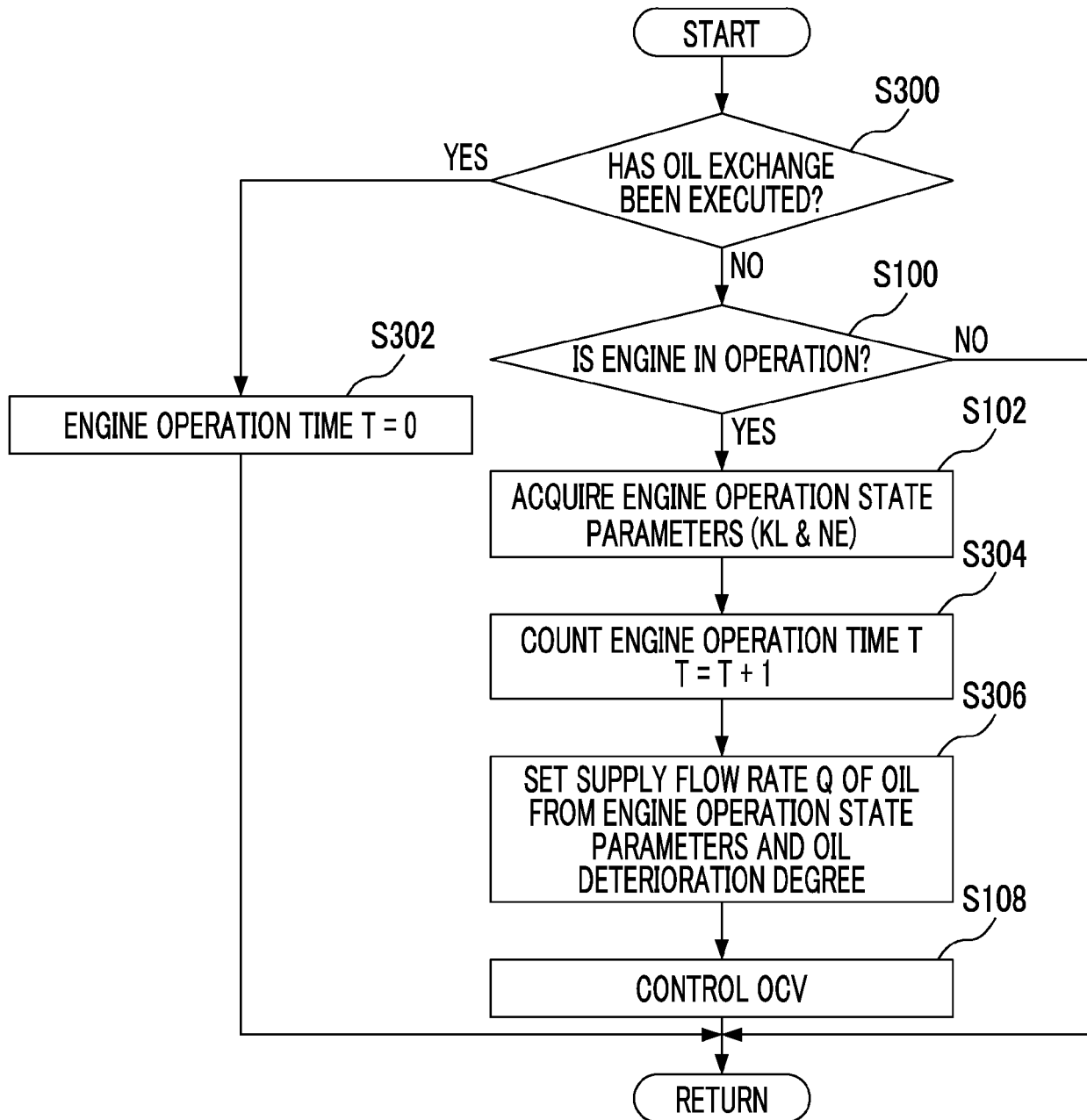


FIG. 8

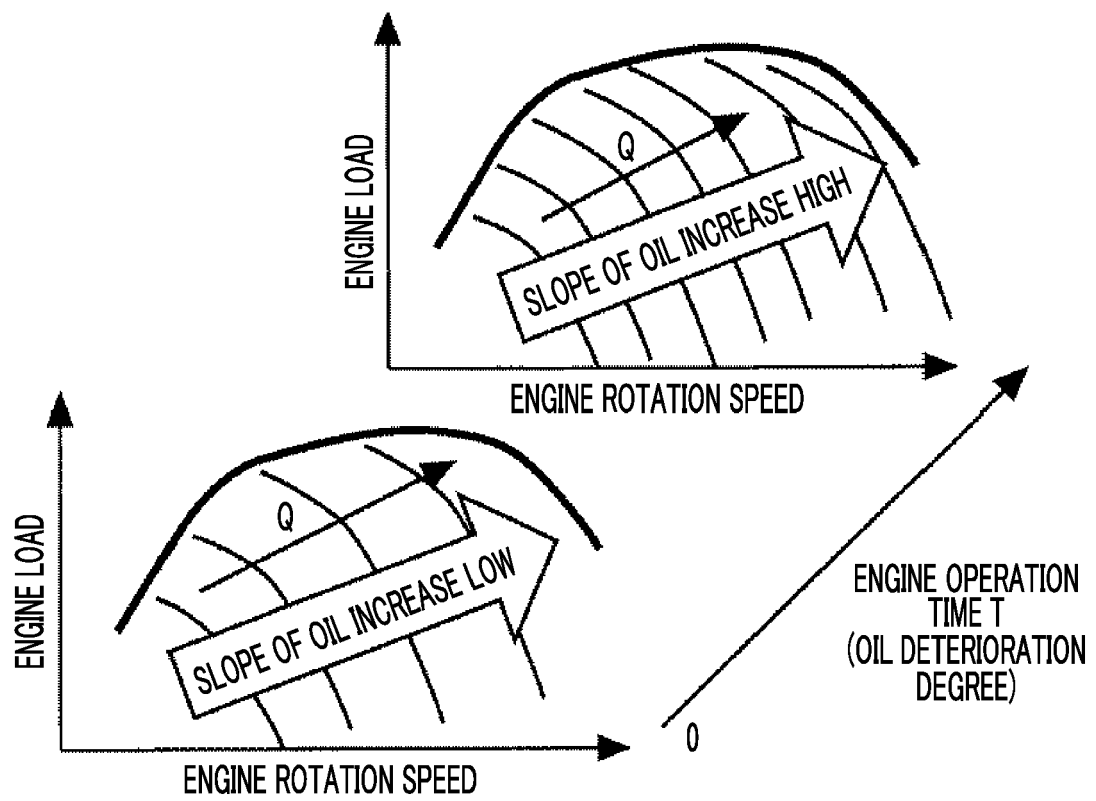


FIG. 9

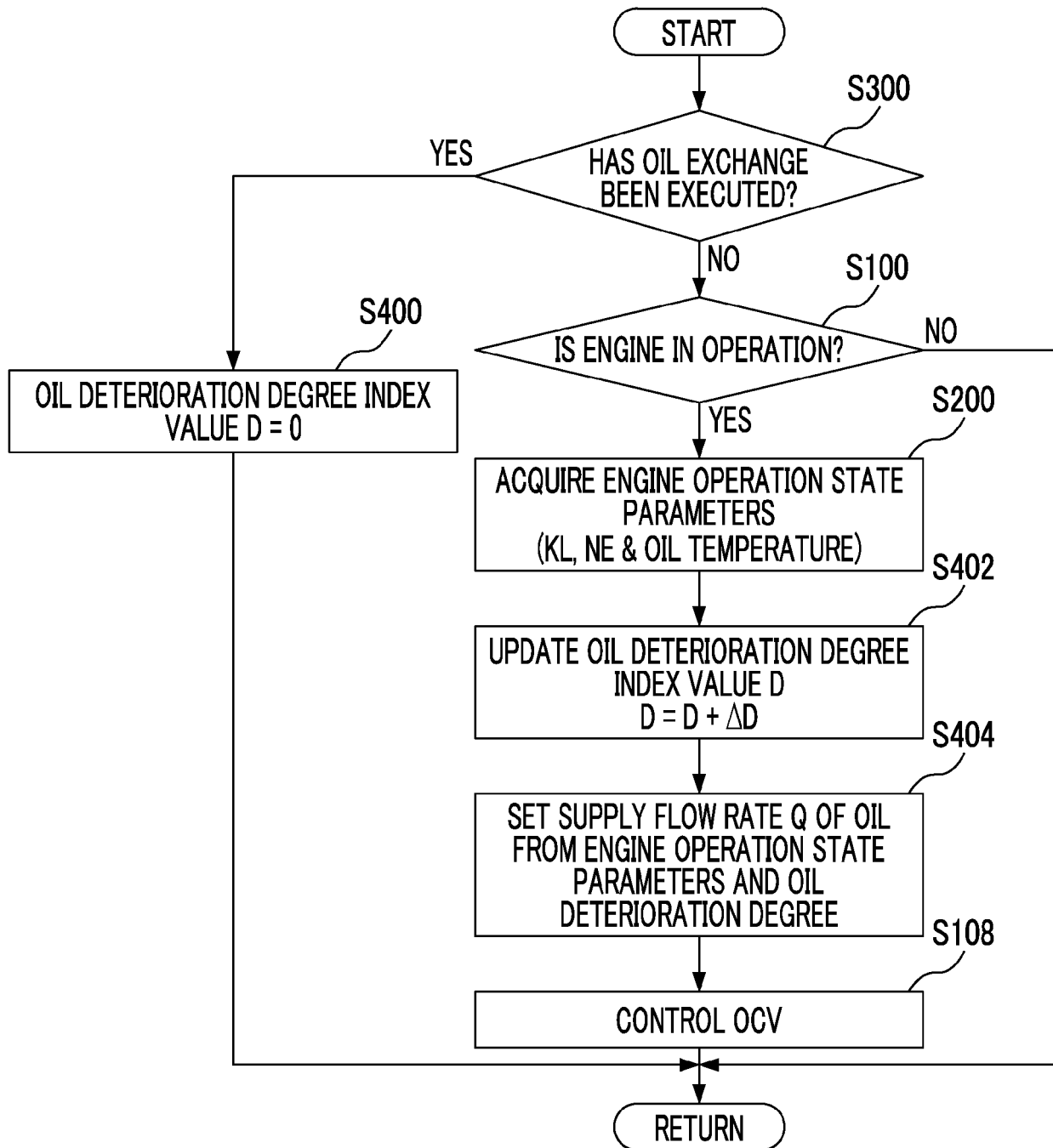
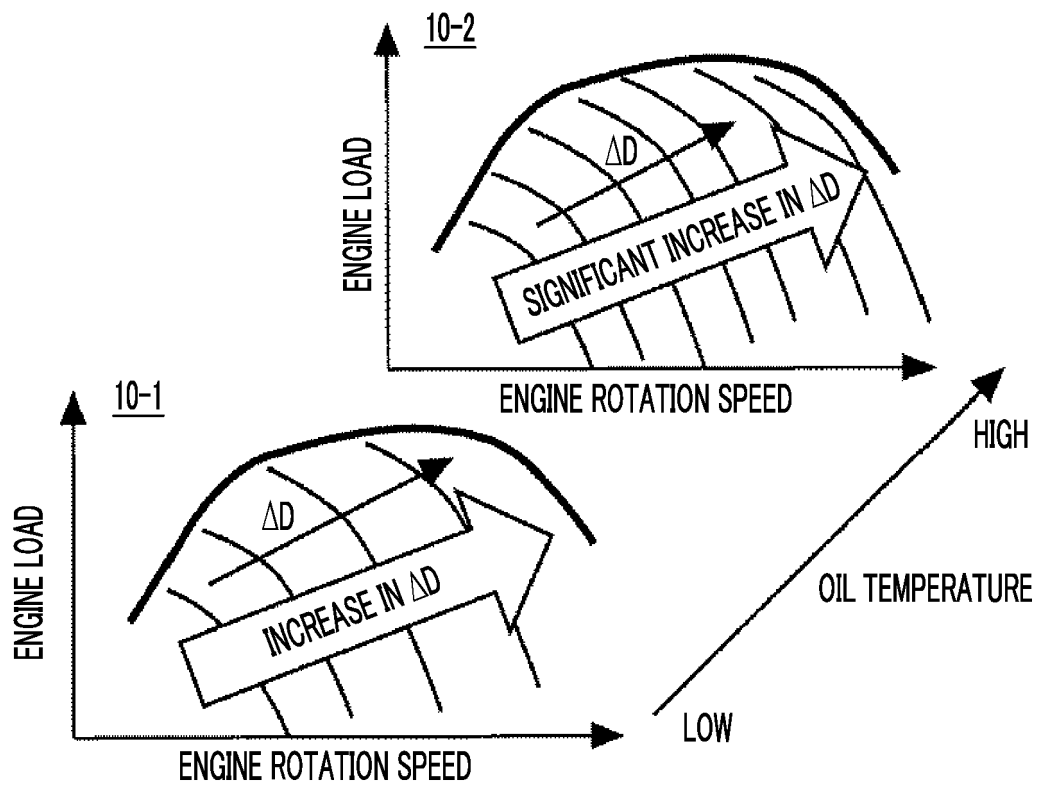


FIG. 10





EUROPEAN SEARCH REPORT

 Application Number
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A	* paragraphs [0013] - [0024], [0043] - [0047] *	3	
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The present search report has been drawn up for all claims			
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The Hague		9 August 2018	Le Bihan, Thomas
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For more details about this annex : see Official Journal of the European Patent Office, No. 12/82

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