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(54) COOLING CONTROL DEVICE

(57) A cooling control device includes: a cooling liquid pump (WP) whose rotational speed is set in accordance with a rotational speed of an engine (E); a cooling flow path (F3) and a heat exchanger (3) which cool cooling liquid discharged from the engine; a flow rate control valve (V) which is provided in the cooling flow path, changes an opening degree by driving a motor (VM), and adjusts a flow rate of the cooling liquid; and a control portion (10) which feedback-controls the opening degree of the flow rate control valve based on a difference between a temperature of the cooling liquid and a target temperature of the cooling liquid, and corrects a gain of the feedback control in accordance with the rotational speed of the engine.

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Description

TECHNICAL FIELD

[0001] This disclosure relates to a cooling control device, more specifically, to a technology which manages the temperature of an engine using a cooling liquid.

BACKGROUND DISCUSSION

[0002] JP 2014-156828A (Reference 1) discloses a cooling device of an engine in which a cooling flow path which circulates cooling water between the engine and a radiator is formed, and which interposes a flow rate control valve and a cooling liquid pump in the cooling flow path. In the cooling device, a control aspect in which an electronic control unit (ECU) sets a target water temperature based on operating conditions or driving conditions of the engine, changes an opening degree of the flow rate control valve after comparing the target water temperature with an actual water temperature, and sets an amount of cooling water which flows to a radiator, is illustrated.

[0003] In the cooling device of Reference 1, considering that a frictional resistance with respect to a seal member or the like is received and control responsiveness of the flow rate control valve deteriorates, an operation amount of feedback control of the flow rate control valve is corrected. Specifically, the operation amount is calculated based on the feedback control in an operation amount calculation portion, it is determined whether the flow rate control valve is in a normal state where an amount of change is small or in an excessive state where the amount of change is large in a state determination portion, and a control amount is corrected when it is determined that the flow rate control valve is in a normal state.

[0004] In a cooling device disclosed in JP 2010-190142A (Reference 2), in order to maintain high responsiveness while suppressing generation of overshoot in flow rate control of a cooling flow path, an operation amount of a flow rate adjusting unit is corrected based on a deviation between a target water temperature and an actual water temperature and a rate of change of the actual water temperature. For example, since there is a possibility of overshooting the target temperature in a case where the deviation is small and the change speed is high, the operation amount may be decreased.

[0005] In a case where the cooling liquid pump is operated by using a driving power of the engine, or the like, the rotational speed of the cooling liquid pump is set in accordance with the rotational speed of the engine. Therefore, the rotational speed of the cooling liquid pump increases as the rotational speed of the engine increases, the flow rate of the cooling flow path increases, and fluid pressure increases. However, in a case where the flow rate control valve receives a high fluid pressure, there is a case where a valve body is pressed to a valve main body and opening and closing becomes difficult. Therefore, for example, when a control gain increases, the control responsiveness of the flow rate control valve becomes excellent when the fluid pressure is high, but when the fluid pressure is low, the opening degree of the flow rate control valve substantially varies vertically from the target opening degree, and hunting is caused. Meanwhile, when the control gain decreases, it is possible to avoid hunting of the flow rate control valve when the fluid pressure is low, but the response of the flow rate control valve becomes slow when the fluid pressure is high. In this manner, in the cooling device of the engine, there is a case where the control responsiveness of the flow rate control valve deteriorates as the fluid pressure of the cooling flow path varies.

SUMMARY

[0006] Thus, a need exists for a cooling control device which can stably maintain control responsiveness of a flow rate control valve.

[0007] A feature of a cooling control device according to an aspect of this disclosure resides in that the cooling control device includes: a cooling liquid pump whose rotational speed is set in accordance with a rotational speed of an engine; a cooling flow path and a heat exchanger which cool cooling liquid discharged from the engine; a flow rate control valve which is provided in the cooling flow path, changes an opening degree by driving a motor, and adjusts a flow rate of the cooling liquid; and a control portion which feedback-controls the opening degree of the flow rate control valve based on a difference between a temperature of the cooling liquid and a target temperature of the cooling liquid, and corrects a gain of the feedback control in accordance with the rotational speed of the engine.

[0008] According to this configuration, the cooling liquid pump whose rotational speed is set in accordance with the rotational speed of the engine, is provided. Therefore, the rotational speed of the cooling liquid pump increases as the rotational speed of the engine increases. According to a change in the rotational speed of the cooling liquid pump, the fluid pressure of the cooling flow path increases and decreases. When the fluid pressure of the cooling flow path increases, there is a case where a valve body of the flow rate control valve is held by the fluid pressure and the opening and closing becomes difficult. Here, in the configuration, the gain of the feedback control is corrected in accordance with the rotational speed of the engine. For example, when the rotational speed of the engine is low and the fluid pressure is low, the correction of lowering the gain of the feedback control is performed, and when the rotational speed of the engine is high and the fluid pressure is high, the correction of increasing the gain of the feedback control is performed. Accordingly, it is possible to suppress hunting or delay of responsiveness in the flow rate control valve. As a result, it is possible to stably perform temperature control of the cooling liquid, and to maintain the temperature of the engine to be within an appropriate range.

[0009] In addition, in the flow rate control valve, there is also a case where the fluid pressure acts as a propulsive force with respect to the opening and closing operation without becoming a resistance force. In this case, the correction may be performed for decreasing the gain as the rotational speed of the engine increases.

[0010] Another feature of the cooling control device according to this disclosure resides in that the gain becomes different in accordance with an opening operation or a closing operation of the flow rate control valve.

[0011] In the flow rate control valve, the acting fluid pressure also becomes different according to the operation direction of the opening operation or the closing operation. In a case where the opening operation is performed with respect to the flow rate control valve, a flow rate of a communication portion which is an open region of the flow rate control valve increases, and the fluid pressure of an inflow portion which is on an upstream side of the valve body deteriorates. Therefore, the resistance force when the opening operation is performed decreases. Meanwhile, in a case where the closing operation is performed, the flow rate of the communication portion decreases, and the fluid pressure of the inflow portion increases. Therefore, the resistance force when the closing operation is performed increases. Here, in this configuration, the gain becomes different in accordance with the opening operation or the closing operation of the flow rate control valve. In the above-described example, the correction is performed so that the gain when the closing operation is performed becomes greater than the gain when the opening operation is performed. Accordingly, it is possible to appropriately set the gain of the feedback control when the opening operation and the closing operation are performed with respect to the flow rate control valve, and to suppress variation of the control responsiveness of the flow rate control valve.

[0012] Another feature of the cooling control device according to this disclosure resides in that the gain becomes different in accordance with the opening degree of the flow rate control valve.

[0013] In the flow rate control valve, the acting fluid pressure also becomes different according to the opening degree. When the flow rate control valve has a low opening degree, the fluid pressure of the inflow portion of the flow rate control valve increases. At this time, since the valve body of the flow rate control valve is pressed to the valve main body, the frictional force with respect to the valve main body becomes the resistance force when the opening operation or the closing operation is performed with respect to the valve body. Meanwhile, when the flow rate control valve has a high opening degree, compared to the lower opening degree, the fluid pressure of the inflow portion is lower. Therefore, in the flow rate control valve having a high opening degree, the resistance force generated based on the fluid pressure of the inflow portion is smaller than that in the flow rate control valve having a low opening degree. In this manner, since the resistance force becomes different when the flow rate control valve is operated according to the opening degree, in this configuration, the gain becomes different in accordance with the opening degree of the flow rate control valve. Similar to the above-described case, in a case where the resistance force decreases as the opening degree of the flow rate control valve increases, the correction is performed so that the gain decreases as the opening degree of the flow rate control valve increases. Accordingly, it is possible to appropriately set the gain of the feedback control of the flow rate control valve even in different opening degrees, and to suppress variation of the control responsiveness of the flow rate control valve.

[0014] Another feature of the cooling control device according to this disclosure resides in that the cooling liquid pump is a mechanical pump which is driven by the engine.

[0015] Similar to this configuration, when the cooling liquid pump is a mechanical pump which is driven by the engine, the rotational speed of the cooling liquid pump is linked with the rotational speed of the engine. Therefore, it is not possible to arbitrarily change the rotational speed of the cooling liquid pump. However, as the gain of the feedback control of the flow rate control valve is corrected in accordance with the rotational speed of the engine, it is possible to appropriately control the temperature of the engine even when the cooling liquid pump is an inexpensive mechanical pump.

BRIEF DESCRIPTION OF THE DRAWINGS

[0016] The foregoing and additional features and characteristics of this disclosure will become more apparent from the following detailed description considered with the reference to the accompanying drawings, wherein:

Fig. 1 is a view illustrating a configuration of a cooling control device;
Fig. 2 is a chart illustrating an opening degree of each valve portion with respect to an operation amount of a valve body;
Fig. 3 is a block diagram illustrating a configuration of a control unit;
Fig. 4 is a block diagram illustrating a configuration of a control unit of another embodiment;
Fig. 5 is a graph illustrating responsiveness of a flow rate control valve of each control gain;
Fig. 6 is a view illustrating a state where the valve body having a high opening degree receives fluid pressure;
Fig. 7 is a view illustrating a state where the valve body having a low opening degree receives fluid pressure;
Fig. 8 is a view illustrating a state where the valve body receives the fluid pressure in a case where the flow direction of the flow body has changed;

Fig. 9 is a view illustrating a state where the valve body having a low opening degree of another embodiment receives fluid pressure; and

Fig. 10 is a view illustrating a state where the valve body having a high opening degree of another embodiment receives fluid pressure.

DETAILED DESCRIPTION

[0017] Hereinafter, the embodiment of the disclosure will be described based on the drawings.

Configuration of Base Body

[0018] As illustrated in Fig. 1, a cooling control device which is provided with a water pump WP (an example of a cooling liquid pump) which sends cooling water (an example of cooling liquid) of an engine E that serves as an internal combustion engine; a plurality of flow paths F which are formed to be aligned; heat exchangers which are provided in each of the plurality of flow paths F; a cooling circuit which controls a flow of the cooling water (an example of the cooling liquid) and is configured of a flow rate control valve V; and a control unit (an example of a control portion) 10 which sets an opening degree of the flow rate control valve V.

[0019] In the cooling control device, a water temperature of the cooling water (cooling liquid) is detected by a water temperature sensor S (an example of a liquid temperature sensor), the control unit 10 controls the flow rate control valve V based on the detection result, and thus, the heat exchange is managed by the heat exchanger.

[0020] As the heat exchanger, an EGR cooler 1, an oil cooler 2, and a radiator 3 which will be described later are provided in the corresponding flow path F. In addition, the water pump WP is disposed in a return flow path FR (a part of the flow path F) between the flow rate control valve V and the engine E.

[0021] The cooling control device is configured to manage the temperature of the engine E (internal combustion engine) of a vehicle, such as a passenger car. The engine E has a water jacket which is formed in a region across a cylinder head from a cylinder block. The cooling control device sends out the cooling water of the water jacket to the flow path F, and allows the cooling water to return to the water jacket by the water pump WP after supplying the cooling water to the heat exchanger and performing the heat exchange. In addition, the engine E transmits a driving power from a crank shaft which serves as an output shaft to a transmission. Furthermore, the engine E can be used generally in the internal combustion engine not being limited to a reciprocating engine. In addition, not being limited to a configuration in which the driving power directly acts on the transmission, for example, the engine E may transmit the driving power to an electric motor similar to a hybrid type vehicle.

Flow Path and Heat Exchanger

[0022] The water temperature sensor S is provided in the engine E, and the plurality of flow paths F through which the cooling water discharged from the engine E is sent and which branches from a main flow path FM, are formed. As the plurality of flow paths F (an example of a cooling flow path), a first flow path F1, a second flow path F2, and a third flow path F3, are formed. As the heat exchanger, the EGR cooler 1 is provided in the first flow path F1, the oil cooler 2 is provided in the second flow path F2, and the radiator 3 is provided in the third flow path F3.

[0023] A technology which takes out a part of exhaust gas of the engine E, improves components in the exhaust gas by returning the exhaust gas to an induction system, or improves fuel efficiency, is referred to as exhaust gas recirculation (EGR), and the EGR cooler 1 performs the heat exchange (cooling) with respect to a part of the exhaust gas taken out of the engine E by the cooling water.

[0024] The oil cooler 2 has a configuration in which lubricating oil stored in an oil pan 5 of the engine E is supplied by an oil pump 6, and performs the heat exchange between the lubricating oil and the cooling water. The lubricating oil to which the heat exchange is performed by the oil cooler 2 is supplied to a hydraulic operating device, such as a valve opening and closing timing control device, or to a lubricating part of each portion of the engine. The oil pump 6 is a variable hydraulic mechanical oil pump which can control a liquid pressure level by 2 steps or more, and is driven by the engine E.

[0025] The radiator 3 has a function of managing the temperature of the engine E by releasing the heat of the cooling water, and cooling wind is supplied by a radiator fan 7. The radiator fan 7 is driven by a fan motor 7M configured of an electric motor.

Flow rate Control Valve

[0026] The flow rate control valve V is configured to be a rotary operating type in which a valve body is freely rotatably accommodated on the inside of a valve case. In addition, a valve motor VM (an example of a motor) which is configured of an electric motor to perform a rotation operation with respect to the valve body, and a valve sensor VS (an example of an opening degree sensor) which detects a rotation angle of the valve body. Furthermore, the flow rate control valve V may also use a sliding operation type in which the valve body that performs a sliding operation is accommodated on the inside of the valve case.

[0027] The flow rate control valve V includes a first valve portion V1 which opens and closes the first flow path F1, a second valve portion V2 which opens and closes the second flow path F2, and a third valve portion V3 which opens and closes the third flow path F3. The opening degree in the first valve portion V1, the second valve portion V2, and the third valve portion V3 with respect to an operation amount of the valve body by the flow rate control valve V having this configuration, is illustrated in Fig. 2. Furthermore, the first valve portion V1, the second valve portion V2, and the third valve portion V3 are generally referred to as a valve portion.

[0028] In Fig. 2, a longitudinal axis illustrates the opening degree of the first valve portion V1, the second valve portion V2, and the third valve portion V3 (the opening degree is illustrated by a percentage), and a horizontal axis illustrates the operation amount (rotation amount) of the valve body. As can be ascertained from the drawing, in a case where the valve body is at an initial position, a fully closed mode M0 in which the first valve portion V1, the second valve portion V2, and the third valve portion V3 are in a closed state is achieved, and the cooling water does not flow to the first flow path F1, the second flow path F2, and the third flow path F3.

[0029] Next, by operating the valve body from the fully closed mode M0 in the opening direction, in a state where the second valve portion V2 and the third valve portion V3 are maintained in a closed state, a first supply mode M1 in which the opening degree of the first valve portion V1 can be adjusted, is achieved.

[0030] Furthermore, by operating the valve body from the first supply mode M1 in the opening direction exceeding a fully opened state, in a state where the opening degree of the first valve portion V1 is maintained to be fully opened (the third valve portion V3 is maintained in a closed state), a second supply mode M2 in which the opening degree of the second valve portion V2 can be adjusted, is achieved.

[0031] In addition, by operating the valve body from the second supply mode M2 in the opening direction exceeding a fully opened state, in a state where the opening degree of the first valve portion V1 and the opening degree of the second valve portion V2 are maintained to be fully opened, a third supply mode M3 in which the opening degree of the third valve portion V3 can be adjusted, is achieved.

[0032] In particular, in the flow rate control valve V, the supply of the cooling water is not performed in the second valve portion V2 before the opening degree of the first valve portion V1 reaches the fully opened state. Similar to this, the supply of the cooling water is not performed in the third valve portion V3 before the opening degree of the second valve portion V2 reaches the fully opened state. Furthermore, not being limited to this configuration, for example, the flow rate control valve V may be provided with four or more valve portions, or may perform the opening operation at the same time in association with the opening degrees of the plurality of valve portions.

Control Unit

[0033] The control unit 10 illustrated in Fig. 3 manages the entire engine, controls a water amount of the cooling water which flows to the flow path F by the flow rate control valve V when operating the engine E, and manages an amount of heat exchanged by the heat exchanger. In particular, in a case where the temperature of the engine E is managed, it is possible to appropriately set the flow rate of the cooling water supplied to the radiator 3 by the control of the flow rate control valve V.

[0034] In the control unit 10, a target flow rate is set based on a difference between the temperature of the cooling water detected by the water temperature sensor S and the target temperature, and a target valve opening degree of the flow rate control valve V is set in accordance with the rotational speed (the rotational speed per unit time) of the engine E to obtain the target flow rate.

[0035] As illustrated in Fig. 3, signals from the water temperature sensor S (liquid temperature sensor), a revolution number sensor 21, and the valve sensor VS (opening degree sensor) are input to the control unit 10. In addition, the control unit 10 outputs a control signal to the valve motor VM which controls the opening degree of the flow rate control valve V.

[0036] The water temperature sensor S is provided in the engine E so as to detect the water temperature of the cooling water, and is configured of a thermistor or the like. The revolution number sensor 21 is configured of a non-contact type sensor which measures the rotational speed of the crank shaft of the engine E, and can detect the rotational speed (the rotational speed per unit time) of the crank shaft from the detection of the revolution number sensor 21.

[0037] The valve sensor VS is configured of a hall IC or a potentiometer, and detects the rotation angle of the valve body of the flow rate control valve V. By the detection, it is possible to detect the opening degree of the valve portion of each supply mode in the flow rate control valve V.

[0038] The control unit 10 is provided with a central processing unit (CPU), a digital signal processor (DSP), an application specific integrated circuit (ASIC), or the like. In addition, in the control unit 10, as necessary, a load correction gain 11, an opening and closing direction correction item 12, and a valve opening degree correction item 13 which are calculated by software, are used.

[0039] In the control unit 10, a supply mode is selected from any of the first supply mode M1, the second supply mode M2, and the third supply mode M3 based on the detection result of the water temperature sensor S. In the first supply mode M1 and the second supply mode M2, the opening degree of the first valve portion V1 and the second valve portion V2 is set based on the detection result of the water temperature sensor S, and the management of the water amount of the cooling water which is supplied to the EGR cooler 1 and the oil cooler 2 is controlled.

[0040] In the third supply mode M3, the target flow rate of the cooling water which is supplied to the radiator 3 by the third flow path F3 is set, the target opening degree of the flow rate control valve V is set based on the rotational speed of the engine E, and the driving of the valve motor VM is controlled to obtain the target opening degree. Furthermore, in the third supply mode M3, the travelling is performed at a low speed, and by the driving of the fan motor 7M when the water temperature is high, the radiator fan 7 is driven, and the cooling wind is supplied to the radiator 3. However, the fan motor 7M is not driven when travelling is performed at a high speed.

[0041] A control state in the third supply mode M3 will be described hereinafter.

[0042] In the control unit 10, the opening degree of the third valve portion V3 (flow rate control valve V) changes, the flow rate of the third flow path F3 is controlled, and the temperature of the engine E is controlled. The control signal is output to the valve motor VM from the control unit 10. The control unit 10 has a PWM circuit which performs PWM control, changes a duty ratio of a pulse width based on a corrected control gain, and controls the valve motor VM. Accordingly, it is possible to easily and rapidly operate the third valve portion V3.

[0043] The target opening degree of the third valve portion V3 is calculated based on the target flow rate of the third flow path F3. The control gain when feedback-controlling the opening degree of the third valve portion V3 is calculated based on a difference between the target opening degree and the actual opening degree.

[0044] Meanwhile, in accordance with the rotational speed of the engine, the load correction gain 11 is calculated in the feedback control of the third valve portion V3. Furthermore, the load correction gain 11 is corrected based on the opening and closing direction correction item 12 and the valve opening degree correction item 13. The opening and closing direction correction item 12 is a parameter which corrects the control gain in accordance with the opening operation or the closing operation of the third valve portion V3. The valve opening degree correction item 13 is a parameter which corrects the control gain in accordance with the opening degree of the third valve portion V3. The control amount and the load correction gain are multiplied based on the actual valve opening degree and the target valve opening degree, the final control gain is obtained, and the control signal is output to the valve motor VM based on the control gain.

[0045] The control unit 10 may be a control aspect which is different from the configuration illustrated in Fig. 3. For example, in the example illustrated in Fig. 4, the load correction gain 11 calculated in accordance with the rotational speed of the engine is multiplied by the control gain based on the actual valve opening degree and the target valve opening degree, and the control gain corrected based on the rotational speed of the engine is obtained. After this, by adding the opening and closing direction correction item 12 and the valve opening degree correction item 13 to the control gain, the final control gain is obtained.

[0046] In Fig. 5, a relationship between the rotational speed of the engine and the fluid pressure (water pressure), and responsiveness of each gain of the feedback control of the opening degree of the third valve portion V3, is illustrated. The rotational speed of the water pump WP is set in accordance with the rotational speed of the engine E. Therefore, when the rotational speed of the engine E is low, the rotational speed of the water pump WP also decreases, and the fluid pressure received by the third valve portion V3 is in a low state. Meanwhile, since the rotational speed of the water pump WP also increases when the rotational speed of the engine E increases, the fluid pressure received by the third valve portion V3 also increases.

[0047] Under the condition, when the gain which is appropriate for high water pressure is set, when the fluid pressure is high, appropriate responsiveness is ensured. However, when the rotational speed of the engine is low and the fluid pressure is low, the valve opening degree substantially varies vertically from the target opening degree, and hunting is caused. Meanwhile, when the gain which is appropriate for low water pressure is set, appropriate responsiveness is ensured when the fluid pressure is low. However, when the rotational speed of the engine increases and the fluid pressure is high, the time period until the valve opening degree becomes the target opening degree becomes longer, and the responsiveness of the feedback control of the valve opening degree deteriorates.

[0048] Meanwhile, in the control unit 10 of the embodiment, the gain of the feedback control is corrected by the load correction gain 11 which is calculated in accordance with the rotational speed of the engine. For example, the negative load correction gain 11 which is appropriate for low fluid pressure is set when the rotational speed of the engine is low, and the load correction gain 11 which is appropriate for high fluid pressure is set when the rotational speed of the engine is high. Accordingly, it is possible to suppress the hunting or the delay of the responsiveness in the third valve portion V3. As a result, it is possible to stably perform the temperature control of the cooling liquid, and to maintain the temperature of the engine within an appropriate range.

[0049] The opening and closing direction correction item 12 is a parameter which corrects the control gain in accordance with the opening and closing direction of the third valve portion V3, that is, the opening operation or the closing operation. A relationship between the opening operation or the closing operation in the operation direction of the third valve portion V3, and the fluid pressure, will be described. In the third valve portion V3, an inflow portion 15 on an upstream side of a valve body 32, a communication portion 16 which is formed every time the valve body 32 is open, and an outflow portion 17 on a downstream side of the valve body 32, are provided. In a rotary valve, in a case where the opening operation is performed with respect to the valve body 32 to achieve a state of Fig. 7 from a state of Fig. 6, the flow rate of the communication portion 16 increases, and the fluid pressure of the inflow portion 15 of the valve body 32 decreases. In addition, in the valve body 32, an open end surface 32a is pressed to the opening operation side by the fluid pressure, the resistance force of the opening operation is reduced.

[0050] Meanwhile, in a case where the closing operation is performed with respect to the valve body 32 to achieve a state of Fig. 6 from a state of Fig. 7, the flow rate of the communication portion 16 decreases, and the fluid pressure of the inflow portion 15 increases. In addition, since high fluid pressure acts on the open end surface 32a in the communication portion 16, the resistance force when the closing operation of the valve body 32 increases. In this manner, in a case where the resistance force is large when the closing operation is performed among the opening operation and the closing operation of the valve body 32, a parameter in which the control gain when the closing operation is performed becomes greater than the control gain when the opening operation is performed, is set as the opening and closing direction correction item 12.

[0051] The valve opening degree correction item 13 is a parameter which corrects the control gain in accordance with the opening degree of the third valve portion V3. A relationship between the opening degree of the third valve portion V3 and the fluid pressure will be described. For example, in the rotary valve, as illustrated in Fig. 6, when the valve body 32 has a low opening degree, the fluid pressure of the inflow portion 15 increases. Therefore, in a case where the opening operation or the closing operation is performed with respect to the valve body 32 from a state of Fig. 6 in which the opening degree is low, the frictional force becomes the resistance force as the valve body 32 is pressed to a valve main body 33.

[0052] Meanwhile, as illustrated in Fig. 7, when the valve body 32 has a high opening degree, compared to a case of Fig. 6 where the opening degree is low, the fluid pressure of the inflow portion 15 is lower. Therefore, in a case where the valve body 32 has a high opening degree, compared to a case where the opening degree is lower, the resistance force which is generated based on the fluid pressure of the inflow portion 15 is small. In this manner, in a case where the resistance force decreases as the opening degree of the valve body 32 increases, a parameter in which the control gain decreases as the opening degree of the third valve portion V3 increases, is set as the valve opening degree correction item 13.

Modification Example of First Embodiment

[0053] In the embodiment, the cooling liquid flows in the orientation opposite to that of the first embodiment with respect to the third valve portion V3. As illustrated in Fig. 8, the arc-like valve body 32 is provided in the outflow portion 17, and the cooling water flows toward the outflow portion 17 from the inflow portion 15. In this case, since the fluid pressure of the inflow portion 15 presses an outer circumferential surface of the arc-like valve body 32, the size or the direction of the fluid pressure received by the valve body 32 becomes different from that of the first embodiment. For example, there is a case where the fluid pressure of the inflow portion 15 acts on the valve body 32 to promote the opening operation. Therefore, in the embodiment, correction of the control gain which is different from that of the first embodiment is performed, for example, the control gain is further reduced when the opening operation of the third valve portion V3 is performed.

Second Embodiment

[0054] In the embodiment, the gate type valve body 32 which is directly operated by the third valve portion V3 (flow rate control valve V), is provided. In this case, as illustrated in Fig. 9, the fluid pressure of the inflow portion 15 acts to hold the valve body 32, and the flow of the fluid of the communication portion 16 also acts on the open end surface 32a of the valve body 32. Here, when the opening operation is performed with respect to the valve body 32 as illustrated in Fig. 10, the flow rate of the communication portion 16 increases, and the fluid pressure of the inflow portion 15 deteriorates. Therefore, when the opening operation is performed with respect to the third valve portion V3, the resistance force received by the valve body 32 tends to decrease.

[0055] Meanwhile, in a case where the closing operation is performed with respect to the valve body 32 to achieve a state of Fig. 9 from a state of Fig. 10, the flow rate of the communication portion 16 decreases, and the fluid pressure of the inflow portion 15 increases. Therefore, when the closing operation is performed with respect to the third valve portion V3, the resistance force received by the valve body 32 tends to increase. Therefore, even in the valve body 32, a parameter in which the control gain when the closing operation is performed becomes greater than the control gain when the opening operation is performed with respect to the third valve portion V3, is set as the opening and closing direction correction item 12.

[0056] In the relationship between the opening degree of the third valve portion V3 and the fluid pressure, as illustrated in Fig. 9, the fluid pressure of the inflow portion 15 increases when the valve body 32 has a low opening degree. Therefore, in a case where the opening operation or the closing operation is performed with respect to the valve body 32 from a state of Fig. 9 where the opening degree is low, the frictional force becomes the resistance force as the valve body 32 is pressed to the valve main body 33. Meanwhile, as illustrated in Fig. 10, when the valve body 32 has a high opening degree, compared to a case of Fig. 9 where the opening degree is low, the fluid pressure of the inflow portion 15 is lower. Therefore, in a case where the valve body 32 has a high opening degree, compared to a case where the opening degree is low, the resistance force which is generated based on the fluid pressure of the inflow portion 15, is smaller.

Other Embodiments

[0057]

(1) In the above-described embodiment, an example in which the gain when feedback-controlling the third valve portion V3 in the third supply mode M3 is corrected by the control unit 10, is described, but similarly, the gain when feedback-controlling the first valve portion V1 in the first supply mode M1 or the second valve portion V2 in the second supply mode M2, may be corrected.

(2) In the above-described embodiment, an example in which the correction is performed so that the gain when feedback-controlling the flow rate control valve V increases as the rotational speed of the engine increases, in the control unit 10, is described, but in a case where the resistance force received by the flow rate control valve V deteriorates as the rotational speed of the engine increases, the correction is performed so that the gain decreases.

(3) In the above-described embodiment, an example in which the parameter in which the control gain when the closing operation of the flow rate control valve V is performed becomes greater than the control gain when the opening operation is performed, is set as the opening and closing direction correction item 12, is described, but in a case where the resistance force when the opening operation is performed among the opening operation and the closing operation is large, a parameter in which the control gain when the opening operation is performed is greater than the control gain when the closing operation of the flow rate control valve V is performed, is set as the opening and closing direction correction item 12.

(4) In the above-described embodiment, an example in which the parameter in which the control gain decreases as the opening degree of the flow rate control valve V increases, is set as the valve opening degree correction item 13, is described, but in a case where the resistance force received by the valve body 32 when the opening degree is high, is greater than the resistance force when the opening degree is low, a parameter in which the control gain increases as the opening degree of the flow rate control valve V increases, is set as the valve opening degree correction item 13.

(5) In the above-described embodiment, an example in which the water pump WP is a mechanical pump which is driven by the engine E, is described, but the water pump WP may be an electric pump. Even when the water pump WP is an electric pump, it is possible to set the rotational speed of the pump in accordance with the rotational speed of the engine E. In a case where the electric pump is used as the water pump WP, the gain of the feedback control may be corrected in accordance with the rotational speed of the pump in the control unit 10. In addition, instead of changing the gain of the feedback control, by making the rotational speed of the water pump WP constant, appropriate responsiveness may be ensured in the feedback control of the flow rate control valve V.

(6) In the above-described embodiment, an example in which the valve body 32 of the flow rate control valve V is formed in a shape of an arc and in a shape of a plate, is described, but the valve body 32 may have other shapes, such as a shape of a spherical body or a circle.

[0058] This disclosure can be used in a cooling control device which manages the temperature of the engine by circulating the cooling liquid.

[0059] The principles, preferred embodiment and mode of operation of the present invention have been described in the foregoing specification. However, the invention which is intended to be protected is not to be construed as limited to the particular embodiments disclosed. Further, the embodiments described herein are to be regarded as illustrative rather than restrictive. Variations and changes may be made by others, and equivalents employed, without departing from the spirit of the present invention. Accordingly, it is expressly intended that all such variations, changes and equivalents which fall within the spirit and scope of the present invention as defined in the claims, be embraced thereby.

[0060] It is explicitly stated that all features disclosed in the description and/or the claims are intended to be disclosed separately and independently from each other for the purpose of original disclosure as well as for the purpose of restricting the claimed invention independent of the composition of the features in the embodiments and/or the claims. It is explicitly stated that all value ranges or indications of groups of entities disclose every possible intermediate value or intermediate entity for the purpose of original disclosure as well as for the purpose of restricting the claimed invention, in particular as limits of value ranges.

Claims

1. A cooling control device comprising:

a cooling liquid pump (WP) whose rotational speed is set in accordance with a rotational speed of an engine (E);

a cooling flow path (F3) and a heat exchanger (3) which cool cooling liquid discharged from the engine;

a flow rate control valve (V) which is provided in the cooling flow path, changes an opening degree by driving a motor (VM), and adjusts a flow rate of the cooling liquid; and

a control portion (10) which feedback-controls the opening degree of the flow rate control valve based on a difference between a temperature of the cooling liquid and a target temperature of the cooling liquid, and corrects a gain of the feedback control in accordance with the rotational speed of the engine.

2. The cooling control device according to claim 1, wherein the gain becomes different in accordance with an opening operation or a closing operation of the flow rate control valve.

3. The cooling control device according to claim 1 or 2, wherein the gain becomes different in accordance with the opening degree of the flow rate control valve.

4. The cooling control device according to any one of claims 1 to 3,
wherein the cooling liquid pump is a mechanical pump which is driven by the engine.

FIG.1

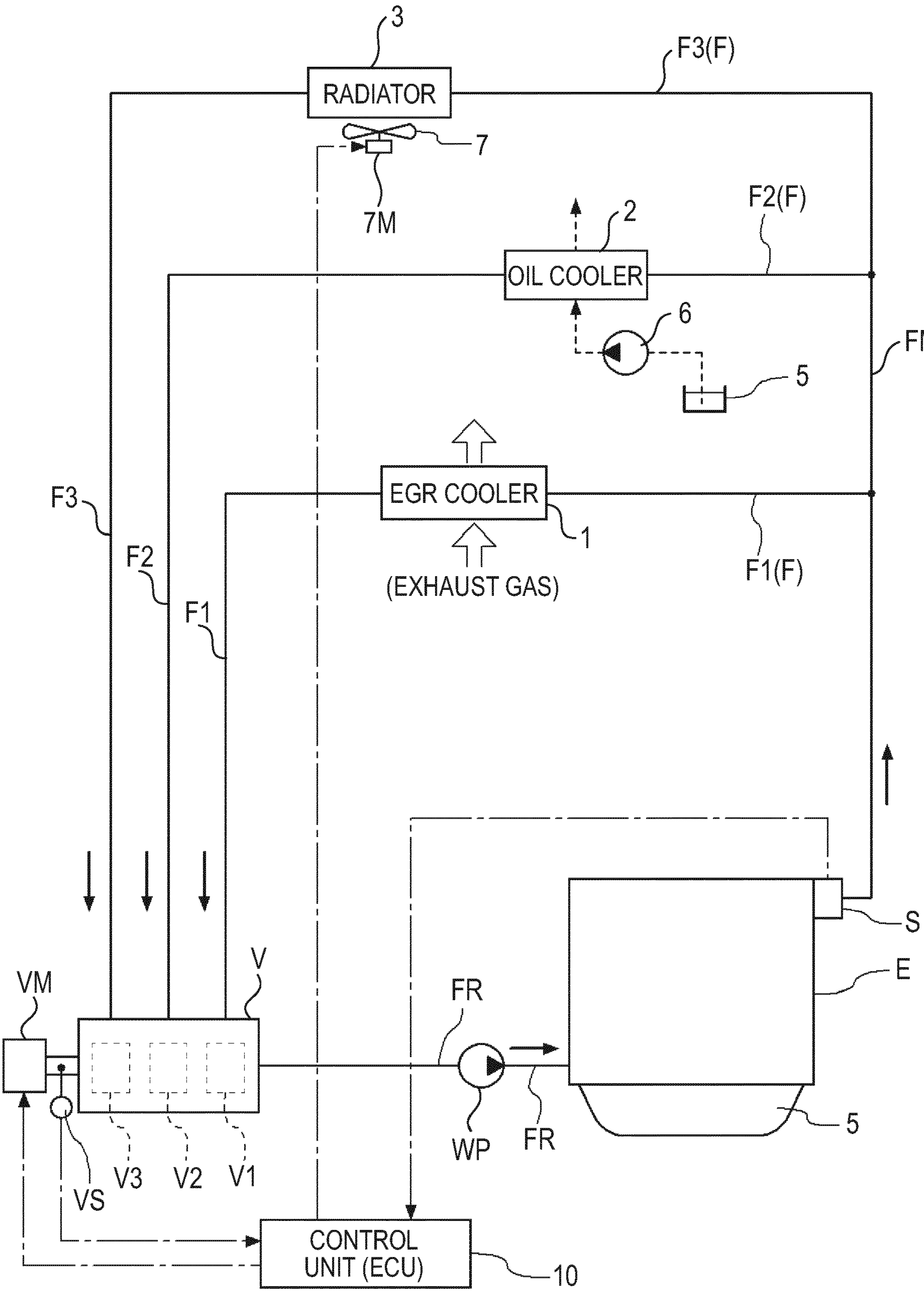
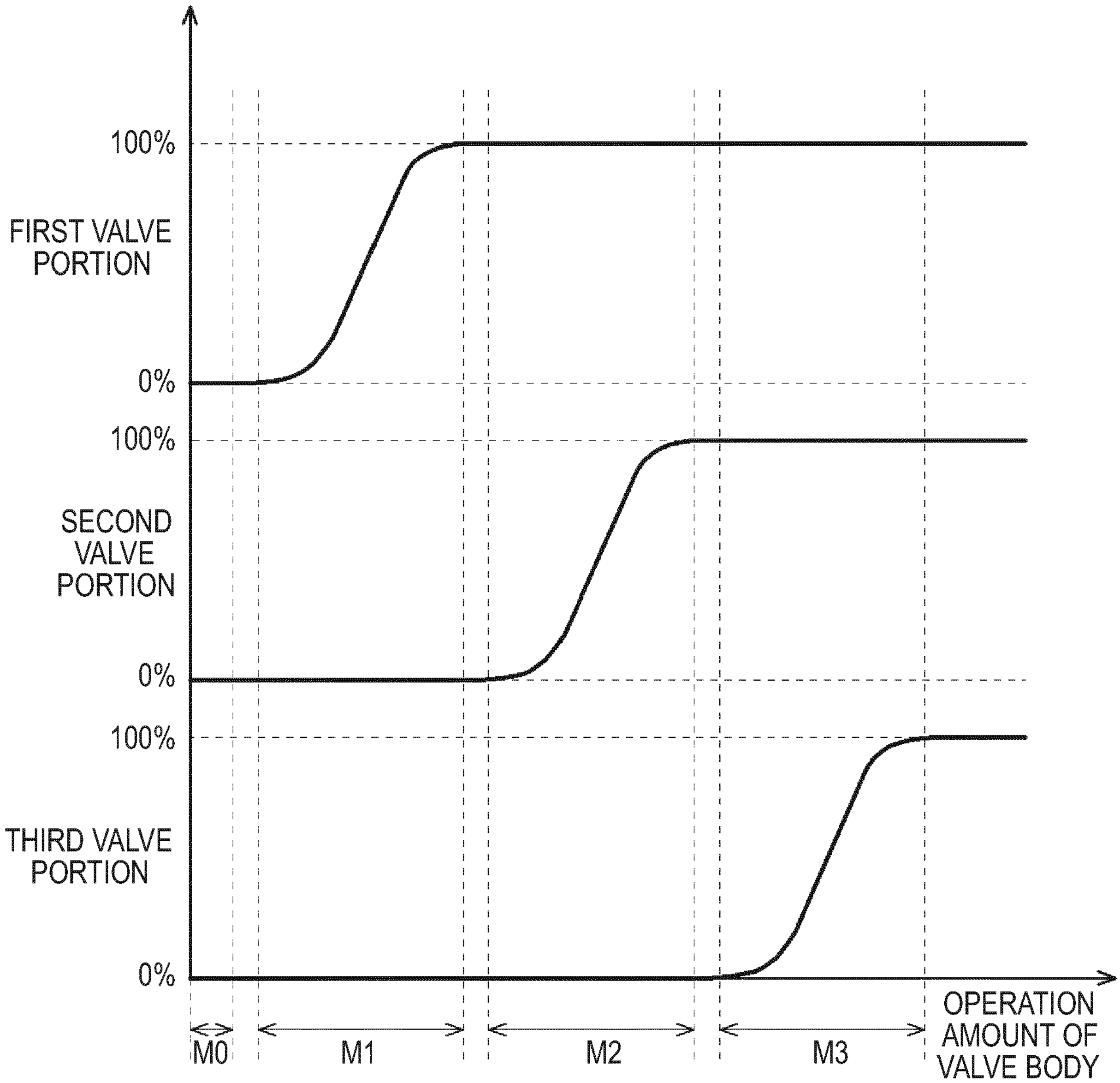

3
RADIATOR
F3(F)
7
7M
2
F2(F)
OIL COOLER
6
FM
5
EGR COOLER
1
F1(F)
(EXHAUST GAS)
F3
F2
F1
V
VM
FR
S
E
WP
FR
5
V3
V2
V1
VS
CONTROL
UNIT (ECU)
10

FIG.2


100%
FIRST VALVE PORTION
0%
100%
SECOND VALVE PORTION
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100%
THIRD VALVE PORTION
0%
M0
M1
M2
M3
OPERATION AMOUNT OF VALVE BODY

FIG.3

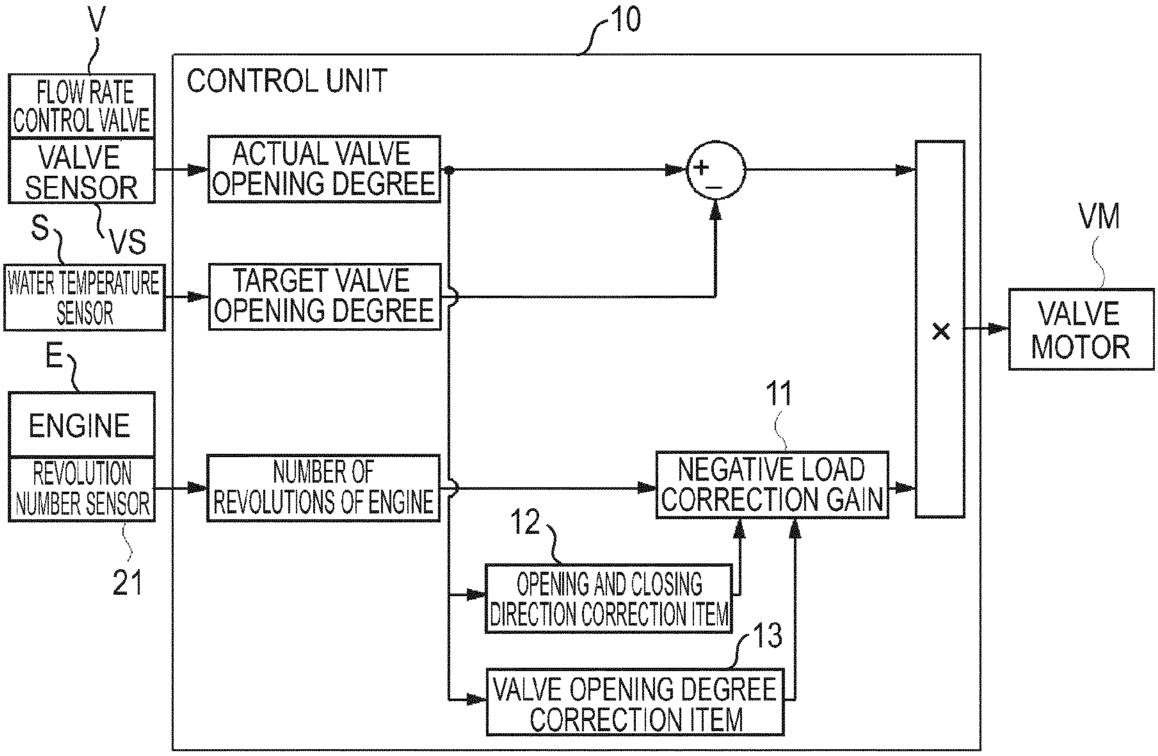

V
10
CONTROL UNIT
FLOW RATE CONTROL VALVE
VALVE SENSOR
ACTUAL VALVE OPENING DEGREE
S
VS
WATER TEMPERATURE SENSOR
TARGET VALVE OPENING DEGREE
E
ENGINE
REVOLUTION NUMBER SENSOR
NUMBER OF REVOLUTIONS OF ENGINE
21
11
NEGATIVE LOAD CORRECTION GAIN
12
OPENING AND CLOSING DIRECTION CORRECTION ITEM
13
VALVE OPENING DEGREE CORRECTION ITEM
×
VM
VALVE MOTOR

FIG.4

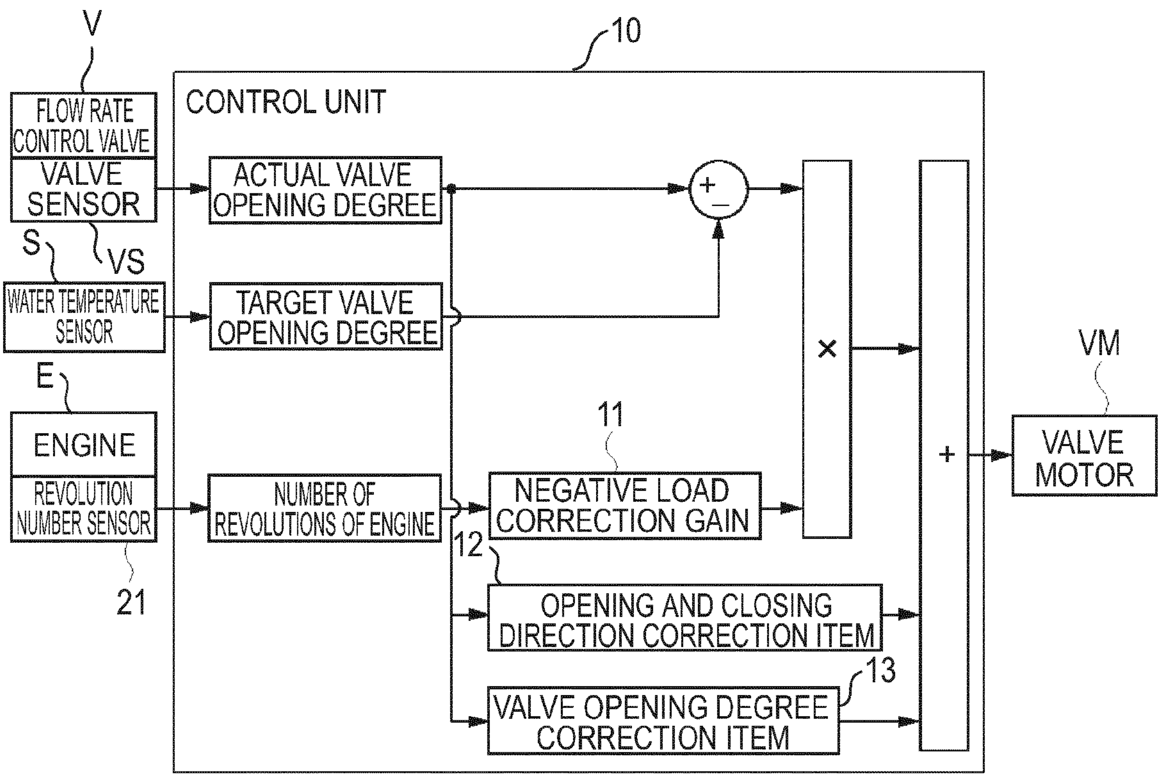

V
10
CONTROL UNIT
FLOW RATE CONTROL VALVE
VALVE SENSOR
ACTUAL VALVE OPENING DEGREE
S
VS
WATER TEMPERATURE SENSOR
TARGET VALVE OPENING DEGREE
E
ENGINE
REVOLUTION NUMBER SENSOR
NUMBER OF REVOLUTIONS OF ENGINE
21
11
NEGATIVE LOAD CORRECTION GAIN
12
OPENING AND CLOSING DIRECTION CORRECTION ITEM
13
VALVE OPENING DEGREE CORRECTION ITEM
×
+
VM
VALVE MOTOR

FIG.5

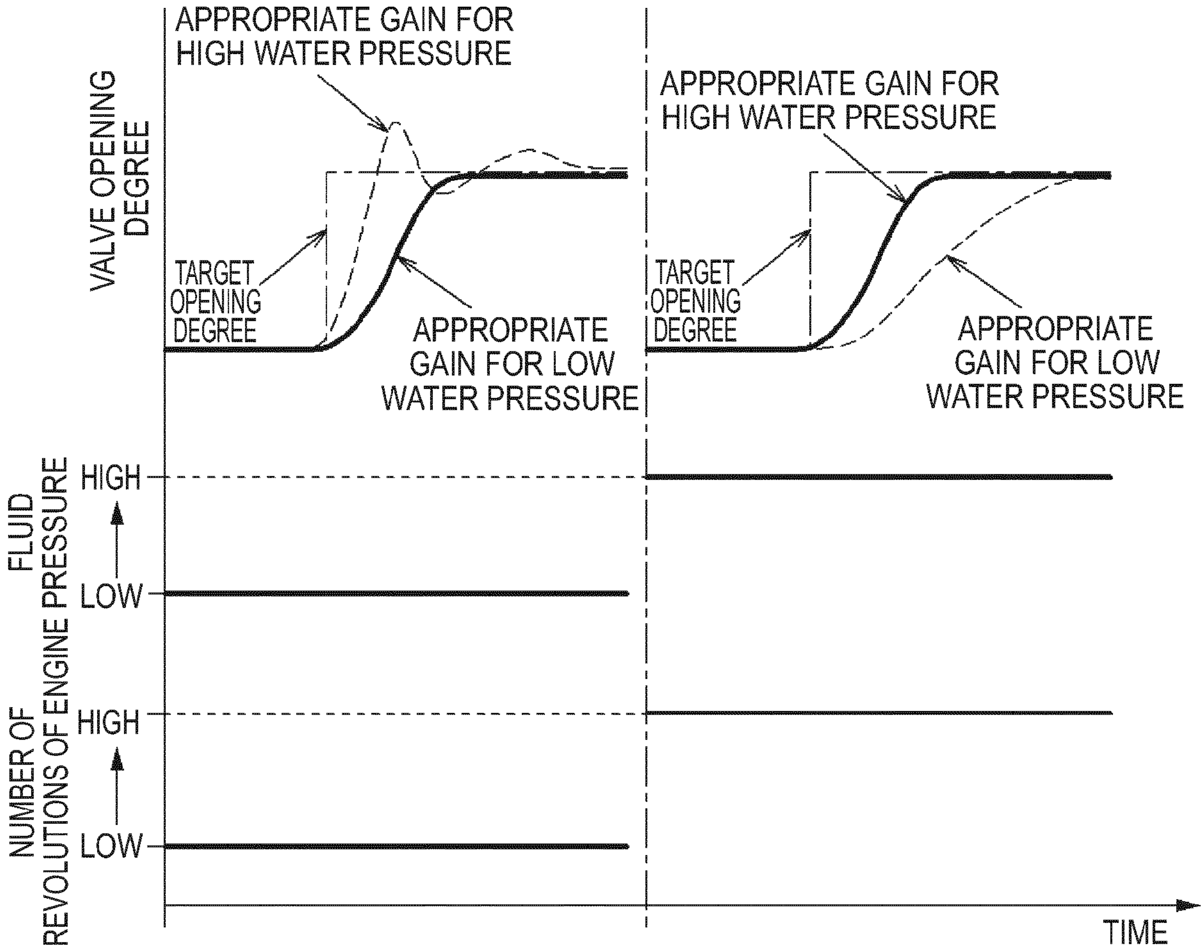

APPROPRIATE GAIN FOR
HIGH WATER PRESSURE
APPROPRIATE GAIN FOR
HIGH WATER PRESSURE
VALVE OPENING
DEGREE
TARGET
OPENING
DEGREE
TARGET
OPENING
DEGREE
APPROPRIATE
GAIN FOR LOW
WATER PRESSURE
APPROPRIATE
GAIN FOR LOW
WATER PRESSURE
FLUID
PRESSURE
HIGH
LOW
NUMBER OF
REVOLUTIONS OF ENGINE
HIGH
LOW
TIME

FIG.6

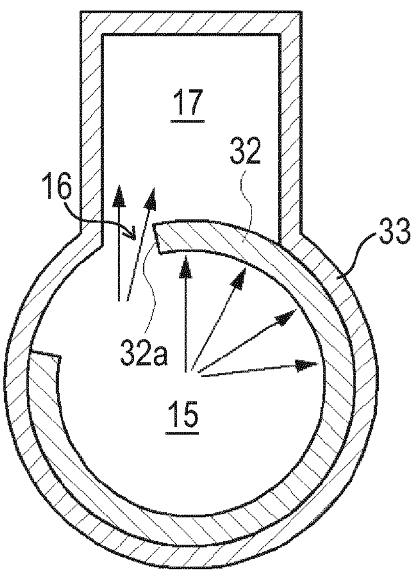

17
32
16
33
32a
15

FIG.7

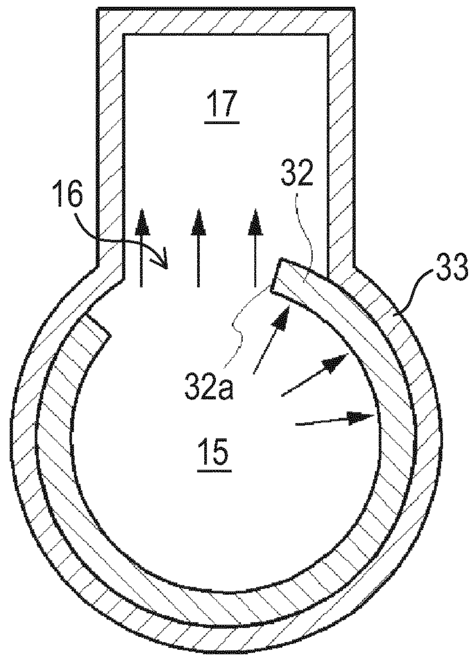


FIG.8

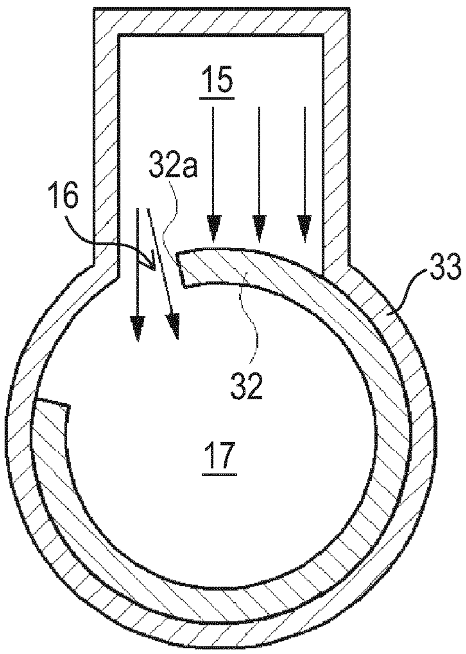


FIG.9

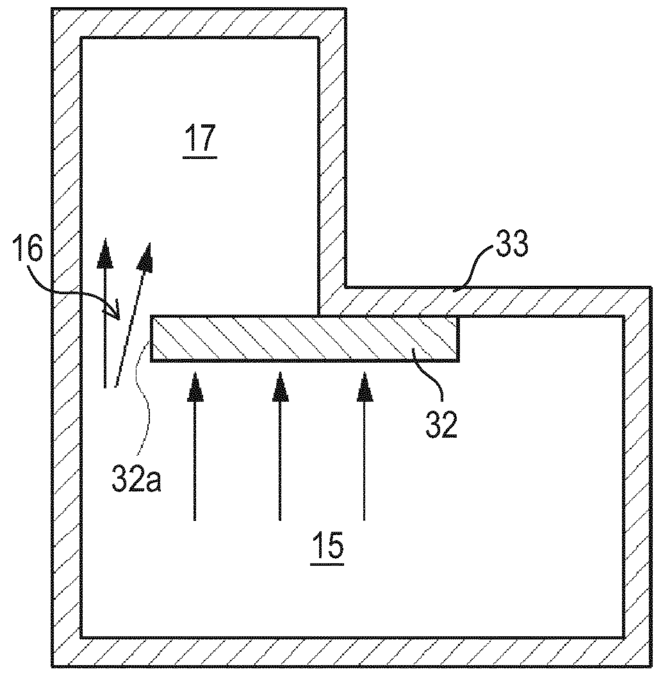
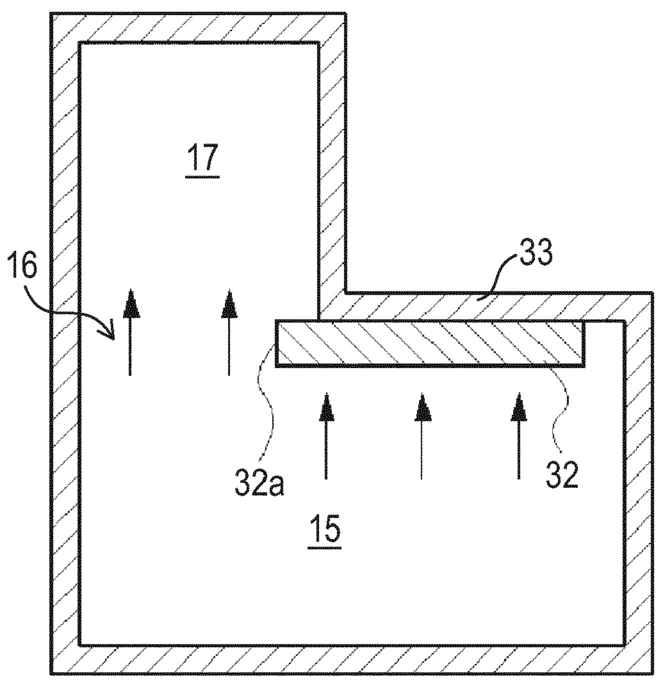


FIG.10



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EUROPEAN SEARCH REPORT

Application Number
EP 16 19 0424

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The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
The Hague	9 February 2017	Matray, J

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