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(54) **METHOD AND SYSTEM FOR CONTROLLING VARIABLE WATER PUMP BASED ON FLOW RATE CONTROL MODES**

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(57) **ABSTRACT**

A method for controlling a variable water pump, in which a variable water pump for circulating a coolant is simultaneously controlled in association with an integrated flow rate control logic which controls a coolant flow based on a driving status of a vehicle, includes controlling the variable water pump to circulate the coolant and an integrated flow rate control valve to control the coolant flow using the integrated flow rate control logic. Flow rate control modes are classified into a heating mode and a fuel efficiency mode in consideration of operation information of an engine and the driving status of the vehicle. An operation of the variable water pump is controlled based on the operation information of the engine and the driving status of the vehicle in the heating mode or the fuel efficiency mode.

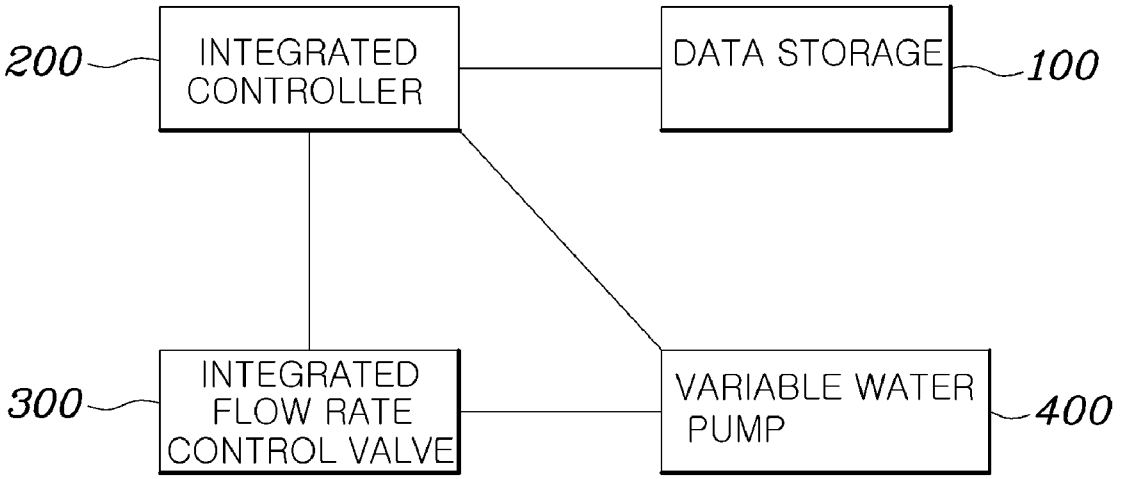


FIG. 1

Related Art

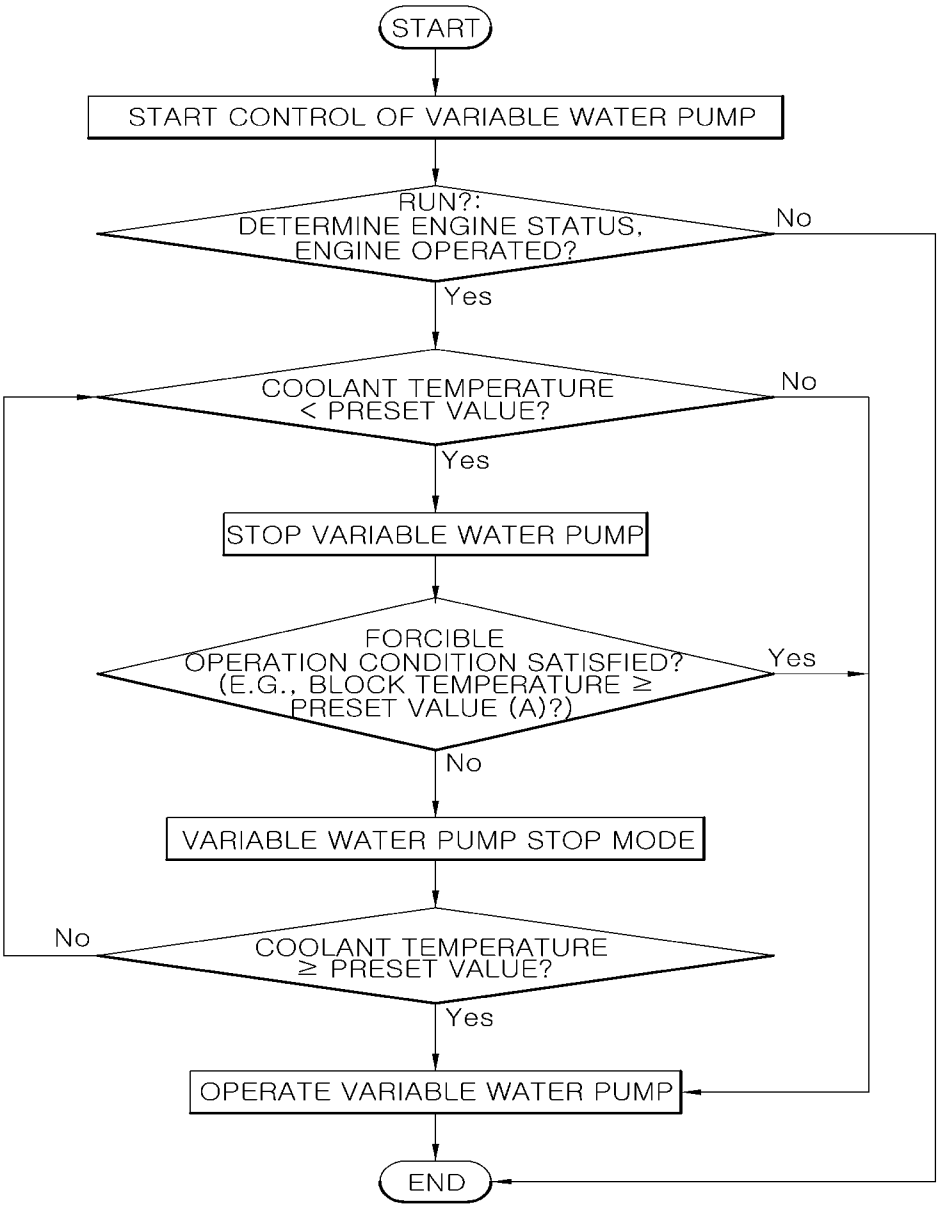


FIG. 2

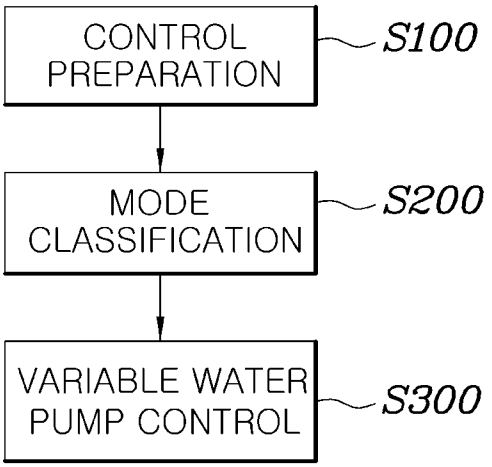

CONTROL PREPARATION
S100
MODE CLASSIFICATION
S200
VARIABLE WATER PUMP CONTROL
S300

FIG. 3

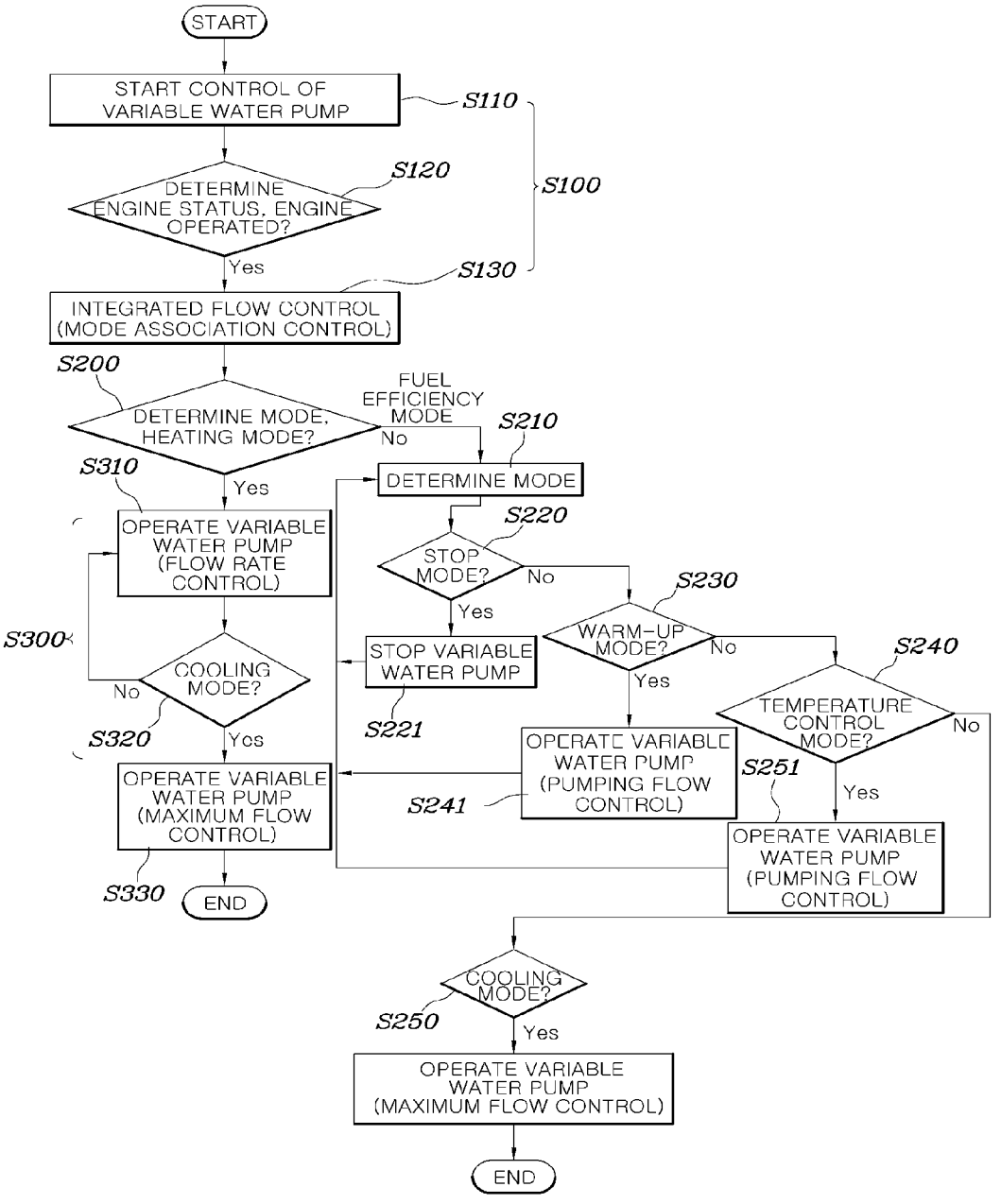
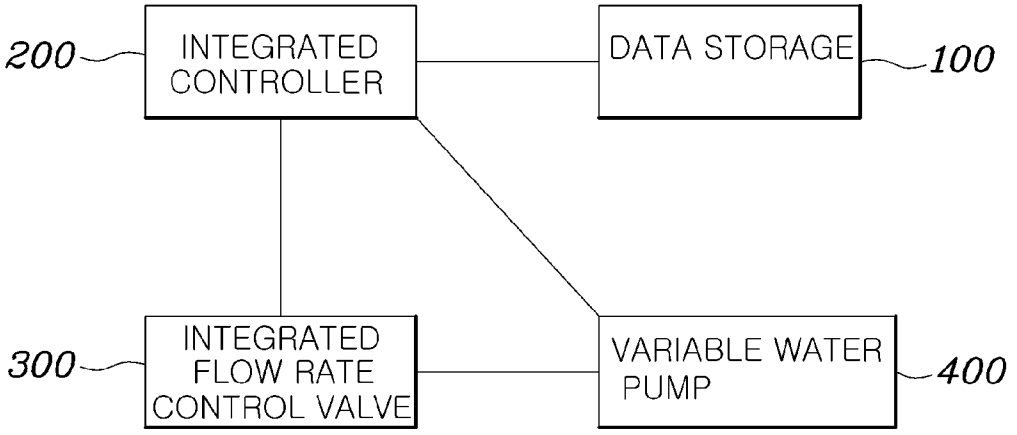

START
START CONTROL OF VARIABLE WATER PUMP
S110
S100
DETERMINE ENGINE STATUS, ENGINE OPERATED?
S120
Yes
S130
INTEGRATED FLOW CONTROL (MODE ASSOCIATION CONTROL)
S200
DETERMINE MODE, HEATING MODE?
FUEL EFFICIENCY MODE
No
S210
DETERMINE MODE
Yes
S310
OPERATE VARIABLE WATER PUMP (FLOW RATE CONTROL)
S220
STOP MODE?
No
Yes
S230
WARM-UP MODE?
No
Yes
S240
TEMPERATURE CONTROL MODE?
No
Yes
S251
S300
COOLING MODE?
No
Yes
S320
STOP VARIABLE WATER PUMP
S221
OPERATE VARIABLE WATER PUMP (PUMPING FLOW CONTROL)
S241
OPERATE VARIABLE WATER PUMP (MAXIMUM FLOW CONTROL)
S330
END
OPERATE VARIABLE WATER PUMP (PUMPING FLOW CONTROL)
COOLING MODE?
S250
Yes
OPERATE VARIABLE WATER PUMP (MAXIMUM FLOW CONTROL)
END

FIG. 4


200
INTEGRATED CONTROLLER
DATA STORAGE
100
300
INTEGRATED FLOW RATE CONTROL VALVE
VARIABLE WATER PUMP
400

METHOD AND SYSTEM FOR CONTROLLING VARIABLE WATER PUMP BASED ON FLOW RATE CONTROL MODES

CROSS REFERENCE TO RELATED APPLICATION

[0001] The present application claims the benefit of priority to Korean Patent Application Number 10-2014-0141675 filed on Oct. 20, 2014, the entire contents of which application are incorporated herein for all purposes by this reference.

TECHNICAL FIELD

[0002] The present disclosure relates generally to a method and system for controlling a variable water pump, and more particularly, to a method and system for controlling a variable water pump based on flow rate control modes, which can efficiently manage heat of an engine and improve fuel efficiency.

BACKGROUND

[0003] An integrated flow rate control valve and a variable water pump have been developed years and will be described below.

[0004] If a coolant temperature is equal to or greater than a preset temperature when a coolant is controlled by using a thermostat, the coolant flows through a radiator, and an active air flap is opened. If the coolant temperature is less than the preset temperature, the air flap is closed to block the coolant flow to the radiator.

[0005] Such a conventional method of controlling the coolant temperature is determined without considering flow rate control modes of the coolant. Accordingly, various technologies have been developed to control vehicle engine parts in order to improve fuel efficiency based on rapid warm-up of an engine in cold start conditions, however, there is still much room for improvement.

[0006] Recently, an integrated flow rate control valve composed of a plurality of motors and valves has been developed and has replaced the above-described thermostat for the flow control of coolant.

[0007] The integrated flow rate control valve comprises the plurality of motors and valves so that the flow rate control modes of the coolant are mainly divided into a stop mode, a warm-up mode, a temperature control mode, a cooling mode depending on an operating status of the engine, and the flow of the coolant can be individually controlled for the respective modes.

[0008] An integrated flow control system to which the above-described integrated flow rate control valve is applied will be described below.

[0009] First, in the stop mode corresponding to an initial start-up of the engine, there is no need to cool the coolant due to a low temperature of the coolant, and thus, the flow of the coolant into the radiator is blocked so that the temperature of the coolant rapidly reaches a normal temperature.

[0010] Next, in the warm-up mode, the coolant is supplied to an oil warmer or a heater only until the engine reaches a normal operation, and most heat generated by the engine is used to warm-up a vehicle. In this case, when the engine warms up to the normal temperature, and the temperature of the coolant becomes equal to or greater than a preset temperature, the integrated flow rate control valve recirculates the coolant through the radiator, thus lowering the temperature of the coolant.

[0011] Further, in the temperature control mode, the coolant temperature of the engine is controlled while the flow rate of the coolant flowing through the radiator increases in stages. In the cooling mode in which the temperature of the coolant is equal to or greater than a reference value, the flow rate of the coolant delivered to the radiator maximally increases, thus more rapidly lowering the temperature of the coolant.

[0012] In general, a vehicle includes a coolant channel, through which the coolant circulates by a water pump, formed in a cylinder block and cylinder head of the engine to prevent overheating of the engine and uniformly maintain the temperature of the engine.

[0013] The water pump is always operated when the engine starts, and the coolant permanently circulates regardless of warm-up conditions or cooling conditions of the engine. Therefore, stabilization of fuel efficiency and exhaust gas may be provided in a state in which the engine is already warmed up. However, when the engine starts in a state in which the engine is fully cooled, a warm-up time of the engine is delayed depending on the circulation of the coolant, thus increasing a frictional resistance in a cooled drive portion and causing engine wear.

[0014] Further, combustion efficiency of the engine deteriorates due to the cooling of the engine, and then, fuel consumption is increased. Also, since a temperature rise of the exhaust gas is delayed, a catalytic activation time is also delayed, and thus, a large amount of harmful material is discharged via the exhaust gas, thus destabilizing emission of the exhaust gas.

[0015] Further, the water pump acts as a load on a crankshaft due to a permanent operation of a fuel pump, thus deteriorating output efficiency of the engine and decreasing fuel efficiency.

[0016] A variable water pump has been utilized in which a clutch is applied to the water pump to solve the above mentioned problems. The water pump is selectively operated by controlling the clutch depending on a revolution per minute (RPM) of the engine, a coolant temperature, and whether a heater for heating operates.

[0017] As shown in FIG. **1**, a variable water pump stops operating when a coolant temperature is less than 95° C. and a temperature of a cylinder block is less than 125° C. Further, when the coolant temperature is greater than 100° C. or the temperature of the cylinder block is greater than 140° C., the variable water pump is operated.

[0018] That is, when a conventional mechanical thermostat is applied to an internal combustion engine, a coolant flow in the engine is controlled using a fixed mechanical value. Accordingly, the variable water pump used in association with the engine is also simply controlled according to a fixed temperature of the coolant or a fixed temperature of the cylinder block.

[0019] According to a conventional technology, the fixed coolant temperature value is applied without sufficiently taking into consideration the flow control of actual engine coolant. As a result, performance control of a vehicle using engine coolant, such as maintenance of heating performance of the vehicle and anti-icing of a throttle body is limited, in addition to basic engine coolant control, such as reduction of an engine warm-up time and improvement of engine cooling performance, are not taken into consideration.

[0020] The present disclosure is intended to provide a method and system for controlling a variable water pump based on flow rate control modes, which can improve fuel efficiency via optimal pumping control of coolant depending on driving conditions of a vehicle according to an integrated flow rate control mode in which a flow rate control mode of the coolant is determined depending on a status of the engine by controlling the above-described variable water pump.

[0021] The foregoing is intended merely to aid in the better understanding of the background of the present disclosure, and is not intended to mean that the present disclosure falls within the purview of the related art that is already known to those skilled in the art.

SUMMARY

[0022] The present disclosure has been made keeping in mind the above problems occurring in the prior art. An aspect of the present inventive concept provides a method and system for controlling a variable water pump based on flow rate control modes, which can improve fuel efficiency by solving problems in the prior art, such as deterioration of heating performance of a vehicle and icing of a throttle body occurring when a variable water pump is simply applied according to control of an integrated flow rate control valve with control of the variable water pump.

[0023] According to an exemplary embodiment of the present inventive concept, a method for controlling a variable water pump, in which a variable water pump for circulating the coolant is controlled in association with the integrated flow rate control logic which controls flow of a coolant depending on a driving status of a vehicle is applied, includes controlling the variable water pump for circulating the coolant and an integrated flow rate control valve for controlling a coolant flow using the integrated flow rate control logic in association with each other. Flow rate control modes are classified into a heating mode and a fuel efficiency mode in consideration of operation information of an engine and a driving status of the vehicle. An operation of the variable water pump is controlled based on the operation information of the engine and the driving status of the vehicle in the heating mode or the fuel efficiency mode.

[0024] The method may further include, in the heating mode, operating the variable water pump. An amount of coolant delivered to a radiator is maximally increased when a current mode is determined to be a cooling mode in which a temperature of the coolant is greater than a reference temperature value while controlling a flow rate of the coolant using the variable water pump.

[0025] The method may further include, in the fuel efficiency mode, dividing the fuel efficiency mode into flow rate control modes according to the integrated flow rate control logic based on the operation information of the engine and the driving status of the vehicle. An operation of the variable water pump is controlled for each flow rate control mode.

[0026] The step of dividing the fuel efficiency mode may include stopping the operation of the variable water pump such that the coolant flow is blocked if a flow rate control mode is determined to be a stop mode which indicates initial start-up of the engine.

[0027] The step of dividing the fuel efficiency mode may include controlling the variable water pump such that only a necessary amount of coolant is supplied to an oil warmer or a heater via the variable water pump if a flow rate control mode is determined to be a warm-up mode which requires warm-up of the engine.

[0028] The step of dividing the fuel efficiency mode may include controlling the variable water pump such that an amount of coolant delivered to a radiator is maximally increased via the variable water pump if a flow rate control mode is determined to be a cooling mode in which a temperature of the coolant is greater than a preset temperature value.

[0029] In another exemplary embodiment, the present inventive concept provides a non-transitory computer-readable recording medium comprising computer executable instructions which cause the integrated controller to perform the method.

[0030] According to another exemplary embodiment of the present inventive concept, a system for controlling a variable water pump based on flow rate control modes includes a data storage configured to store operation information of an engine, a driving status of a vehicle, and temperature information of a coolant. An integrated controller is configured to classify the modes into a plurality of preset modes using an integrated flow rate control logic depending on the information stored in the data storage and to control operations of the variable water pump according to the preset modes.

[0031] The integrated controller may classify the modes into a heating mode and a fuel efficiency mode based on the information stored in the data storage and may control the operations of the variable water pump according to respective classified modes.

[0032] The integrated controller may operate the variable water pump if a current mode is determined to be the heating mode and control the variable water pump such that an amount of coolant delivered to a radiator is maximally increased if it is determined that a temperature of the coolant, measured in real time and stored in the data storage, is greater than a reference value during operation of the variable water pump.

[0033] The integrated controller may divide the fuel efficiency mode into preset flow rate control modes of an integrated flow rate control valve based on the data stored in the data storage if a current mode is determined to be the fuel efficiency mode and may control an operation of the variable water pump for each flow rate control mode.

[0034] The integrated controller may stop the operation of the variable water pump to block a coolant flow if the flow rate control mode is determined to be a stop mode which indicates initial start-up of an engine.

[0035] The integrated controller may control the variable water pump such that only a necessary amount of coolant is supplied to an oil warmer or a heater via the variable water pump if a flow rate control mode is determined to be a warm-up mode which requires warm-up of the engine.

[0036] The integrated controller may control the variable water pump such that an amount of coolant delivered to a radiator is maximally increased if a flow rate control mode is determined to be a cooling mode in which a temperature of the coolant is greater than a reference temperature value.

BRIEF DESCRIPTION OF THE DRAWINGS

[0037] The above and other objects, features and advantages of the present disclosure will be more clearly understood from the following detailed description taken in conjunction with the accompanying drawings.

[0038] FIG. **1** is a diagram showing control logic of a conventional variable water pump.

[0039] FIG. **2** is a flowchart showing a method for controlling a variable water pump based on flow rate control modes according to the present disclosure.

[0040] FIG. **3** is a detailed flowchart showing individual steps of the method according to the present disclosure.

[0041] FIG. **4** is an overall configuration diagram showing a system for controlling a variable water pump based on flow rate control modes according to the present disclosure.

DETAILED DESCRIPTION

[0042] Hereinafter, embodiments of a method and system for controlling a variable water pump based on flow rate control modes according to the present disclosure will be described in detail with reference to the accompanied drawings.

[0043] According to the present disclosure, when an integrated flow rate control logic for controlling a coolant flow depending on a driving status of a vehicle is applied, a variable water pump for circulating a coolant is simultaneously controlled in association with the integrated flow rate control logic.

[0044] More specifically, a control logic according to the present disclosure is capable of controlling an integrated flow rate control valve comprising a plurality of motors and valves such that the flow rate control modes of the coolant are mainly divided into a stop mode, a warm-up mode, a temperature control mode, a cooling mode depending on an operating status of an engine and the coolant flow can be controlled for each flow rate control mode, and the control logic of the variable water pump for circulating the coolant are operated in association with each other.

[0045] Coolant control of a conventional variable water pump is implemented in association with the above-described stop mode, warm-up mode, temperature control mode, and cooling mode.

[0046] FIG. **2** is a flowchart showing a method for controlling a variable water pump based on flow rate control modes according to the present disclosure, and FIG. **3** is a detailed flowchart showing individual steps of the method for controlling the variable water pump according to the present disclosure.

[0047] As shown in the drawings, the method of the present disclosure includes control preparation step **S100**, mode classification step **S200**, and variable water pump control step **S300**.

[0048] The control preparation step **S100** is a preparing control step in which a variable water pump for circulating coolant and an integrated flow rate control valve for controlling flow of a coolant depending on an integrated flow rate control logic may be controlled in association with each other. In order to implement this step, as shown in FIG. **3**, the control of the variable water pump is initiated at step **S110**. Here, an electronic control unit (ECU) controls such a variable water pump.

[0049] Thereafter, it is determined whether the engine runs at step **S120**. When the engine is running, the integrated flow rate control logic capable of controlling the integrated flow rate control valve is applied at step **S130**.

[0050] This integrated flow rate control valve is also controlled by the ECU. In this case, the engine runs, and the control of the integrated flow rate control mode is initiated in association with the control of the variable water pump at step **S130**.

[0051] Thereafter, as shown in the drawing, the mode classification step **S200** is implemented where modes are classified in consideration of operation information of the engine and a driving status of the vehicle.

[0052] That is, the modes are classified into a heating mode in which heating of the vehicle takes precedence over driving of the vehicle, and a fuel efficiency mode in which fuel efficiency may be improved depending on the driving of the vehicle rather than the heating of the vehicle. Those modes are classified by the ECU using various types of vehicle information such as s temperature of outdoor air, a driving time of the vehicle, and a current temperature of the vehicle.

[0053] By classifying the modes into the heating mode and the fuel efficiency mode, deterioration of heating performance of the vehicle and icing of a throttle body may be prevented.

[0054] After the mode classification step **S200**, variable water pump control step **S300** is performed in which the operation of the variable water pump is controlled in consideration of the operation information of the engine and the driving status of the vehicle in a classified heating mode and a fuel efficiency mode.

[0055] That is, as shown in FIG. **3**, if it is determined that a current mode is the heating mode, a coolant flow rate is controlled normally at step **S310**. Then, if it is determined at step **S320** that the current mode is the cooling mode in which a coolant temperature is greater than a reference temperature value, the coolant temperature is lowered by maximally increasing the amount of coolant that can flow through the radiator at step **S330**, instead of executing the normal coolant flow rate control mode for the heating mode.

[0056] Accordingly, if the current mode is determined to be the heating mode, the coolant flow of the variable water pump is controlled to maintain the heating mode. Then, when the temperature of the coolant becomes greater than the reference value, the flow rate of the coolant flowing through the radiator is maximized, and thus, the heating performance of the vehicle may improve compared to a case where only the conventional variable water pump is installed.

[0057] If the current mode is determined to be the fuel efficiency mode, a procedure of dividing the fuel efficiency mode into flow rate control modes according to the integrated flow rate control logic based on the operation information of the engine and the driving status of the vehicle is performed at step **S210**. Thereafter, a procedure of controlling the operation of the variable water pump for each flow rate control mode is performed.

[0058] That is, as a result of considering the operation information of the engine and the driving status of the vehicle, if it is determined that there is a need to perform control so that a driving status of the vehicle for reduction in fuel consumption meets an optimized condition in consideration of the driving of the vehicle, rather than providing precedence to heating, the step of controlling the variable water pump for respective flow rate control modes, that is, the stop mode the warm-up mode the temperature control mode the cooling mode, is performed.

[0059] In order to implement this step, the procedure of dividing the fuel efficiency mode into flow rate control modes set according to the integrated flow rate control logic, based on the operation information of the engine and the driving

status of the vehicle, and the procedure of controlling the operations of the variable water pump depending on the results of the division are performed.

[0060] In this case, in the stop mode **S220** indicating the initial start-up of the engine, the coolant temperature is typically low and there is no need to cool the coolant, and thus, the flow of the coolant flowing through the radiator must be blocked so that the coolant temperature reaches the normal temperature thereof. Then, the operation of the variable water pump is stopped to block the flow of the coolant flowing through the radiator at step **S221**.

[0061] In warm-up mode **S230** in which the engine reaches a normal operation, the coolant is supplied only to an oil warmer or a heater via the integrated flow rate control valve, and the heat of the engine is controlled for raising the temperature of the coolant at step **S231**. In this mode, the variable water pump is controlled such that only required coolant is supplied to the oil warmer or heater and such that the temperature of the coolant is raised by the heat of the engine.

[0062] Then, in temperature control mode **S240**, the variable water pump is controlled so that the temperature of the coolant is controlled by increasing the flow rate of the coolant delivered to the radiator in stages at step **S241**. In cooling mode **S250**, it is determined that the temperature of the coolant is greater than the preset reference value. Therefore, in this mode, the variable water pump is controlled so that the temperature of the coolant is lowered by maximizing the flow rate of the coolant delivered to the radiator at step **S251**.

[0063] That is, unlike the conventional control procedure of the variable water pump performed according to the fixed temperature of the coolant, in the present disclosure, the operations of the variable water pump are divided for respective modes in consideration of vehicle information and driving status depending on the integrated flow rate control logic upon controlling the variable water pump, and thus, the variable water pump is controlled in consideration of the flow of the coolant of the engine in each mode.

[0064] In contrast, FIG. **4** is an overall configuration diagram showing a system for controlling a variable water pump based on flow rate control modes according to the present disclosure.

[0065] As shown in the figures, the system of the present disclosure mainly includes a data storage **100** for storing the operation information of the engine, the driving status of the vehicle, and the temperature information of coolant. An integrated controller **200** classifies the flow rate control modes into a plurality of preset modes using an integrated flow rate control logic depending on the information stored in the data storage **100** and controls operations of a variable water pump **400** depending on preset modes.

[0066] In this case, the integrated control unit **200** classifies the modes into a heating mode and a fuel efficiency mode based on the information stored in the data storage **100**, and controls the operations of the variable water pump **400** depending on respective classified modes.

[0067] Further, the integrated controller **200** operates the variable water pump **400** if a current mode is determined to be the heating mode, and controls the variable water pump **400** such that, if the temperature of the coolant, measured in real time and stored in the data storage **100** during the operation of the variable water pump **400**, is determined to be greater than a preset reference value, the amount of coolant delivered to the radiator is maximized.

[0068] The integrated controller **200** further, if it is determined that the current mode is the fuel efficiency mode, divides the fuel efficiency mode into preset flow rate control modes of an integrated flow rate control valve **300**, based on the data stored in the data storage **100**, and control the operation of the variable water pump **400** for each flow rate control mode.

[0069] Furthermore, the integrated controller **200** is configured to, if the flow rate control mode is determined to be a stop mode indicating the initial start-up of the engine, stop the operation of the variable water pump **400** to block the flow of coolant. If the flow rate control mode is determined to be a warm-up mode in which the warm-up of the engine is required, the integrated controller **200** controls the variable water pump **400** so that only required coolant is supplied to the oil warmer or the heater via the variable water pump **400**, whereas if the flow rate control mode is determined to be a cooling mode in which the temperature of the coolant is greater than a reference temperature value, the integrated controller **200** controls the variable water pump **400** so that the amount of coolant delivered to the radiator is maximized.

[0070] A detailed operating procedure has been described above, and thus, a detailed description thereof will be omitted here.

[0071] As described above, the system according to the present disclosure controls the variable water pump in association with the integrated flow rate control logic, upon controlling the variable water pump, thus realizing various effects, such as optimizing the improvement of fuel efficiency, and also improving the heating performance of the vehicle and preventing icing of a throttle body via the application of the variable water pump.

[0072] In accordance with the method and system for controlling the variable water pump based on flow rate control modes according to the present disclosure having the above configuration, the present disclosure controls a variable water pump in association with the control of a so-called integrated flow rate control valve that has been developed, upon controlling the variable water pump, thus realizing various effects, such as improving fuel efficiency, and also preventing problems caused by the application of the conventional variable water pump, that is, deterioration of heating performance of the vehicle and icing of the throttle body.

[0073] Although the present inventive concept has been illustrated and described in relation to specific embodiments, those skilled in the art will appreciate that various modifications, additions and substitutions are possible, without departing from the scope and spirit of the disclosure as disclosed in the accompanying claims.

What is claimed is:

1. A method for controlling a variable water pump, wherein a variable water pump for circulating a coolant is simultaneously controlled in association with an integrated flow rate control logic which controls a coolant flow based on a driving status of a vehicle, the method comprising steps of:

controlling, by an integrated controller, the variable water pump to circulate the coolant and an integrated flow rate control valve to control the coolant flow using the integrated flow rate control logic;

classifying, by an integrated controller, flow rate control modes into a heating mode and a fuel efficiency mode in consideration of operation information of an engine and the driving status of the vehicle; and

controlling, by an integrated controller, an operation of the variable water pump based on the operation information of the engine and the driving status of the vehicle in the heating mode or the fuel efficiency mode.

2. The method of claim **1**, wherein, in the heating mode, the step of controlling the operation of the variable water pump comprises steps of:

operating the variable water pump; and

maximally increasing an amount of coolant delivered to a radiator when a current mode is determined to be a cooling mode in which a coolant temperature is greater than a reference temperature value while controlling a flow rate of the coolant using the variable water pump.

3. The method of claim **1**, wherein, in the fuel efficiency mode, the step of classifying the modes comprises steps of:

dividing the fuel efficiency mode into flow rate control modes according to the integrated flow rate control logic based on the operation information of the engine and the driving status of the vehicle; and

controlling the operation of the variable water pump for each flow rate control mode.

4. The method of claim **3**, wherein the step of dividing the fuel efficiency mode comprises a step of stopping the operation of the variable water pump so that the coolant flow is blocked if a flow rate control mode is determined to be a stop mode which indicates initial start-up of the engine.

5. The method of claim **3**, wherein the step of dividing the fuel efficiency mode comprises a step of controlling the variable water pump so that only a necessary amount of coolant is supplied to an oil warmer or a heater via the variable water pump if a flow rate control mode is determined to be a warm-up mode which requires warm-up of the engine.

6. The method of claim **3**, wherein the step of dividing the fuel efficiency mode comprises a step of controlling the variable water pump so that an amount of coolant delivered to a radiator is maximally increased via the variable water pump if a flow rate control mode is determined to be a cooling mode in which a coolant temperature is greater than a reference temperature value.

7. A non-transitory computer-readable recording medium comprising computer executable instructions which cause the integrated controller to perform the method according to claim **1**.

8. A system for controlling a variable water pump according to flow rate control modes, the system comprising:

a data storage configured to store operation information of an engine, a driving status of a vehicle, and temperature information of coolant; and

an integrated controller configured to classify the modes into a plurality of preset modes using an integrated flow rate control logic depending on the information stored in the data storage and to control operations of the variable water pump according to the preset modes.

9. The system of claim **8**, wherein the integrated controller classifies the modes into a heating mode and a fuel efficiency mode based on the information stored in the data storage, and controls the operations of the variable water pump according to corresponding modes.

10. The system of claim **9**, wherein the integrated controller is configured to operate the variable water pump if a current mode is determined to be the heating mode, and to control the variable water pump such that an amount of coolant delivered to a radiator is maximally increased if a temperature of the coolant, which is measured in real time and stored in the data storage, is greater than a reference temperature value during an operation of the variable water pump.

11. The system of claim **9**, wherein the integrated controller is configured to:

divide the fuel efficiency mode into preset flow rate control modes of an integrated flow rate control valve based on the data stored in the data storage if a current mode is determined to be the fuel efficiency mode, and

control an operation of the variable water pump for each flow rate control mode.

12. The system of claim **11**, wherein the integrated controller stops the operation of the variable water pump to block a coolant flow if a flow rate control mode is determined to be a stop mode which indicates initial start-up of the engine.

13. The system of claim **11**, wherein the integrated controller controls the variable water pump so that only a necessary amount of coolant is supplied to an oil warmer or a heater via the variable water pump if a flow rate control mode is determined to be a warm-up mode which requires warm-up of the engine.

14. The system of claim **11**, wherein the integrated controller controls the variable water pump such that an amount of coolant delivered to a radiator is maximally increased if a flow rate control mode is determined to be a cooling mode in which a temperature of the coolant is greater than a reference temperature value.

* * * * *