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(54) **COOLING SYSTEM FOR VEHICLE AND CONTROL METHOD THEREFOR**

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(57) **ABSTRACT**

Disclosed are a cooling system for a vehicle and a control method for a cooling system. The cooling system may include an electric water pump configured to circulate coolant, an active air flap apparatus configured to actively control an air amount introduced into an engine room of the vehicle, a radiator configured to supply the coolant to an engine, a fan configured to cool the coolant of the radiator, and a control unit configured to control the electric water pump, the air flap apparatus, and the fan depending on a driving state and condition of the vehicle, in which the radiator is directly connected to the electric water pump without a thermostat or a control value being interposed between the radiator and the electric water pump.

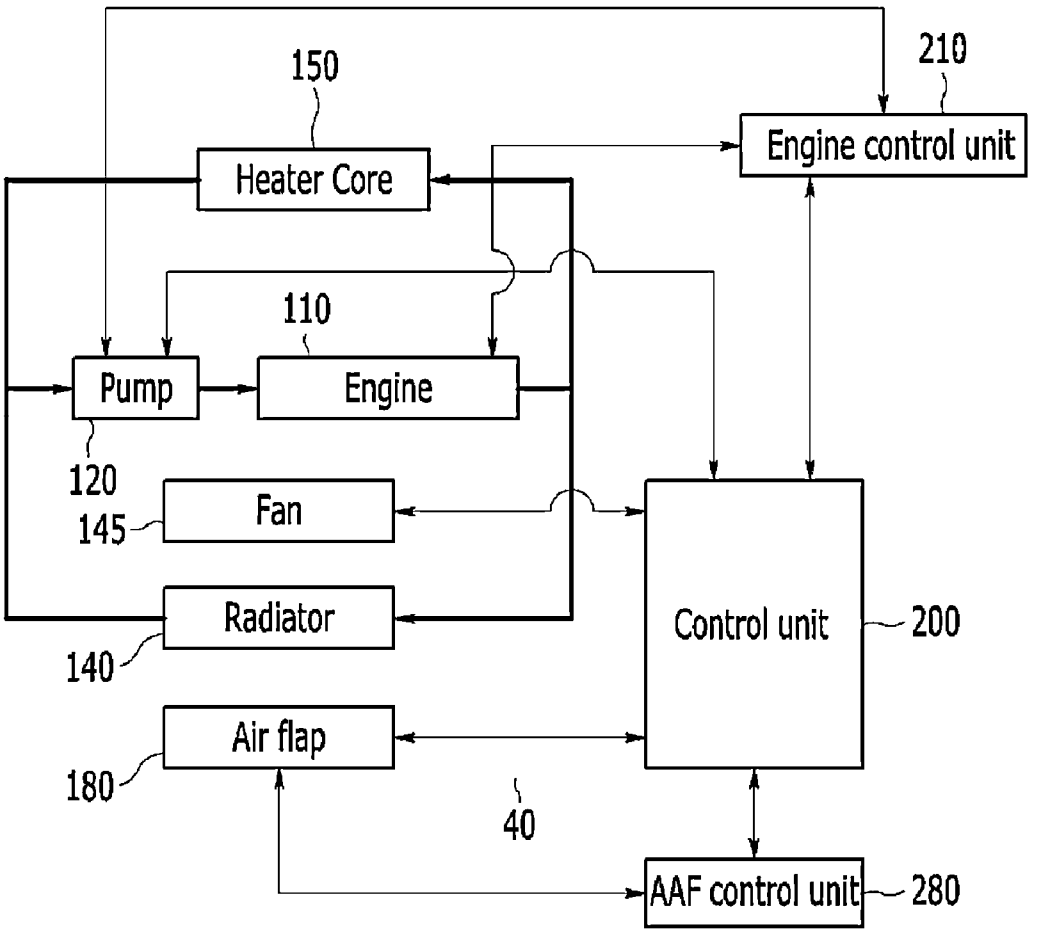


FIG. 1 (Related Art)

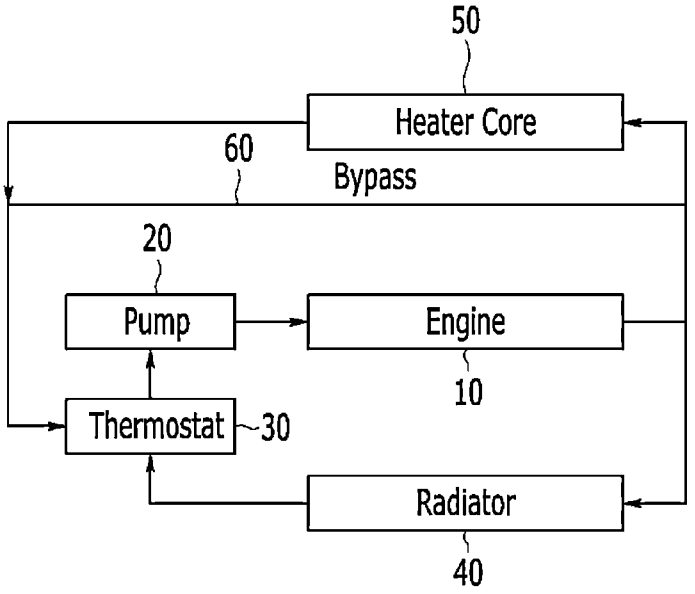


FIG. 2 (Related Art)

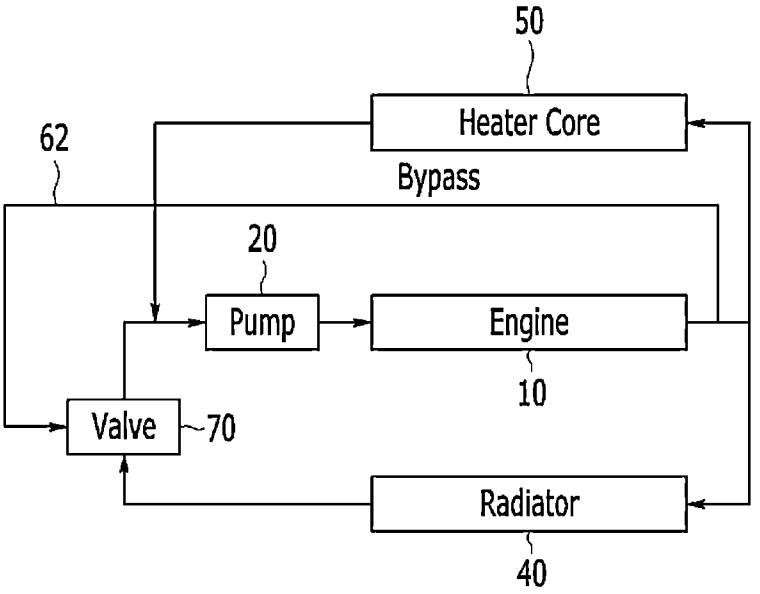


FIG. 3 (Related Art)

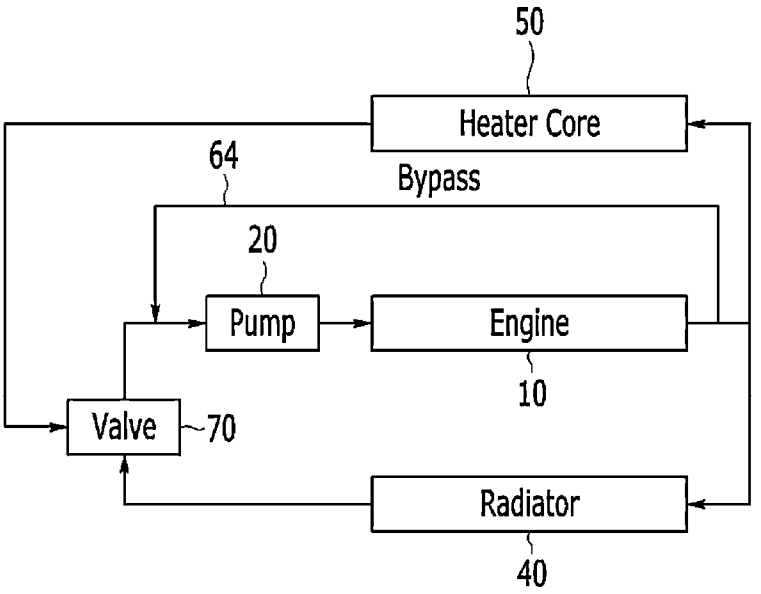


FIG. 4

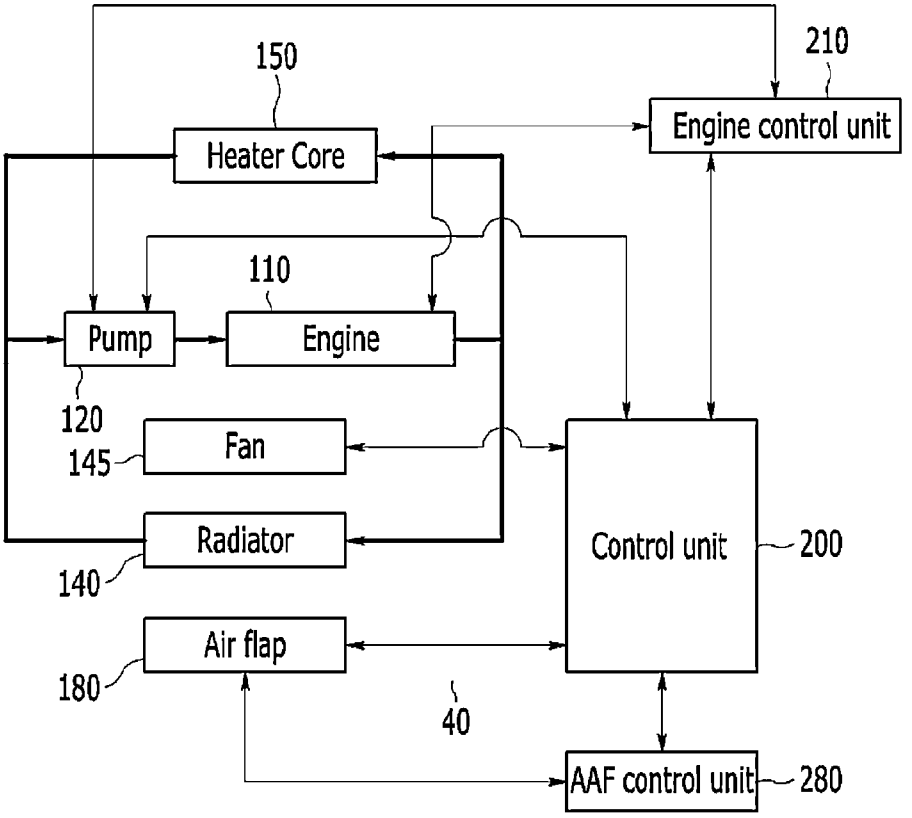

150
210
Heater Core
Engine control unit
110
Pump
Engine
120
145
Fan
Radiator
140
Control unit
200
Air flap
180
40
AAF control unit
280

FIG. 5

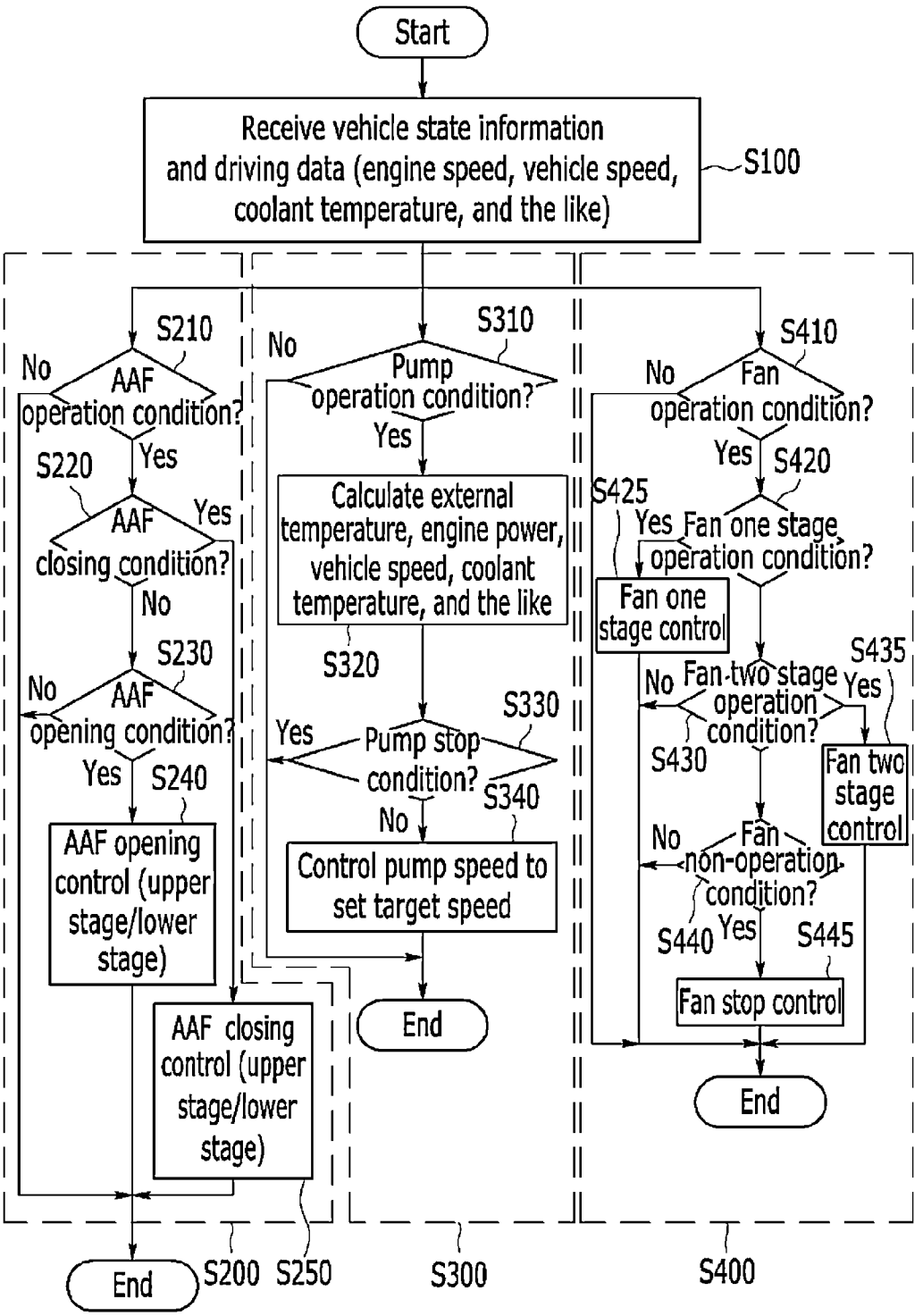

Start
Receive vehicle state information and driving data (engine speed, vehicle speed, coolant temperature, and the like)
S100
S210
AAF operation condition?
No
Yes
S220
AAF closing condition?
Yes
No
S230
AAF opening condition?
No
Yes
S240
AAF opening control (upper stage/lower stage)
AAF closing control (upper stage/lower stage)
S310
Pump operation condition?
No
Yes
Calculate external temperature, engine power, vehicle speed, coolant temperature, and the like
S320
S330
Pump stop condition?
Yes
No
S340
Control pump speed to set target speed
End
S410
Fan operation condition?
No
Yes
S420
S425
Fan one stage operation condition?
Yes
Fan one stage control
S435
Fan two stage operation condition?
No
Yes
S430
Fan two stage control
Fan non-operation condition?
No
S440
Yes
S445
Fan stop control
End
End
S200
S250
S300
S400

FIG. 6

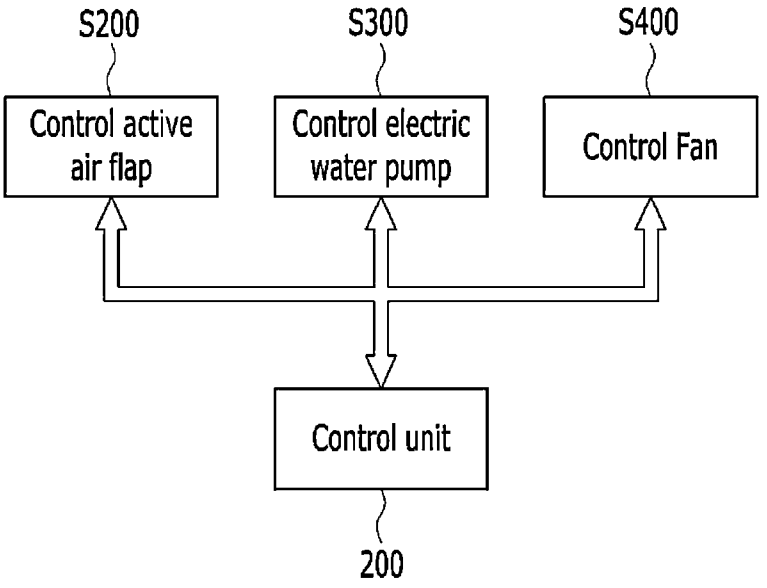

S200
S300
S400
Control active air flap
Control electric water pump
Control Fan
Control unit
200

FIG. 7

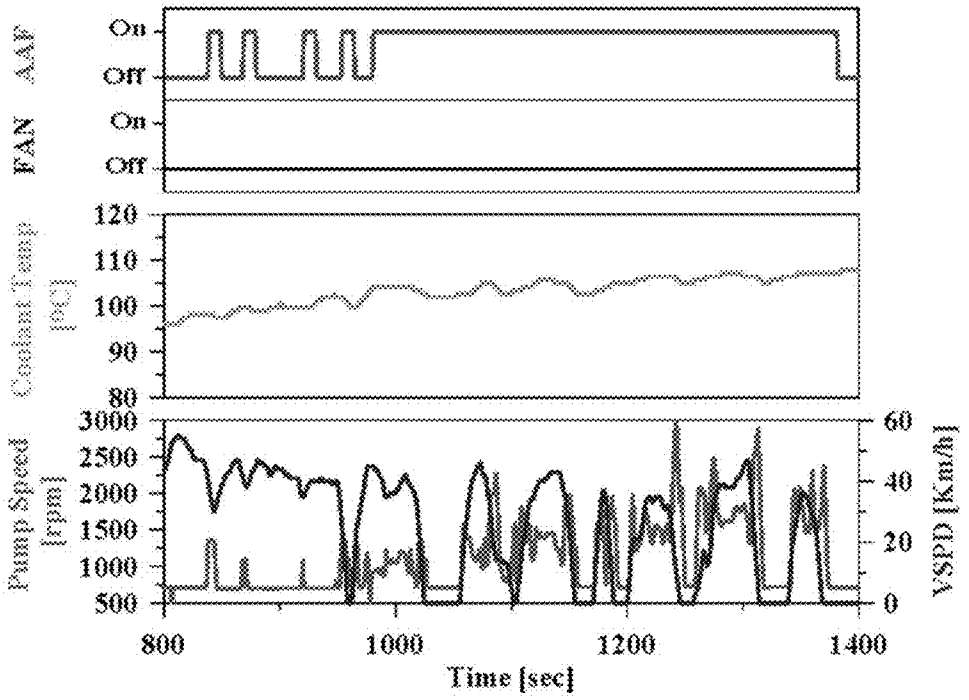

AAF
On
Off
FAN
On
Off
Coolant Temp [℃]
120
110
100
90
80
Pump Speed [rpm]
3000
2500
2000
1500
1000
500
VSPD [Km/h]
60
40
20
0
800
1000
1200
1400
Time [sec]

FIG. 8

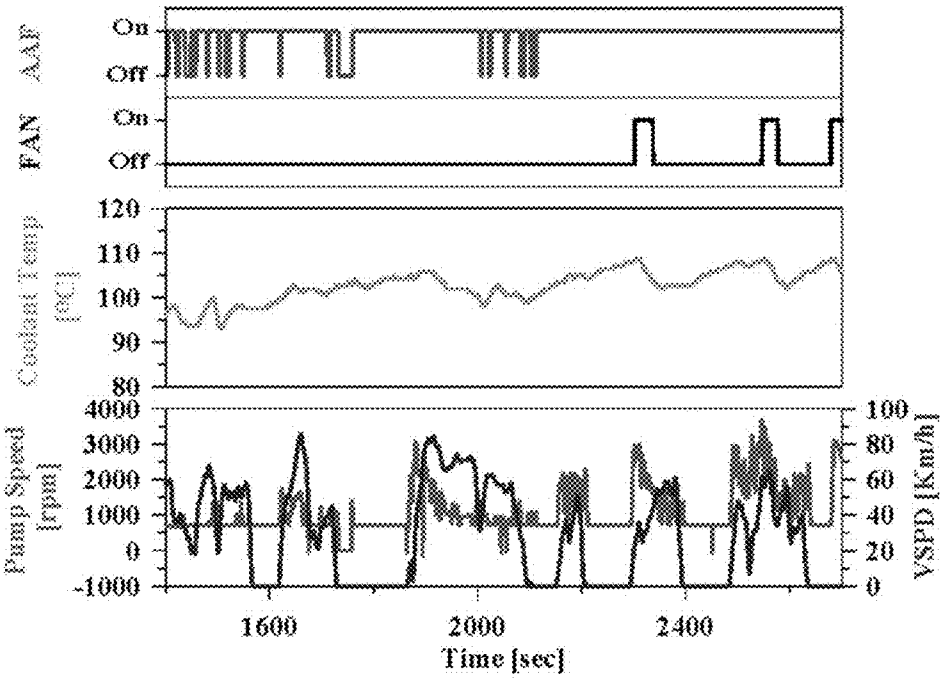
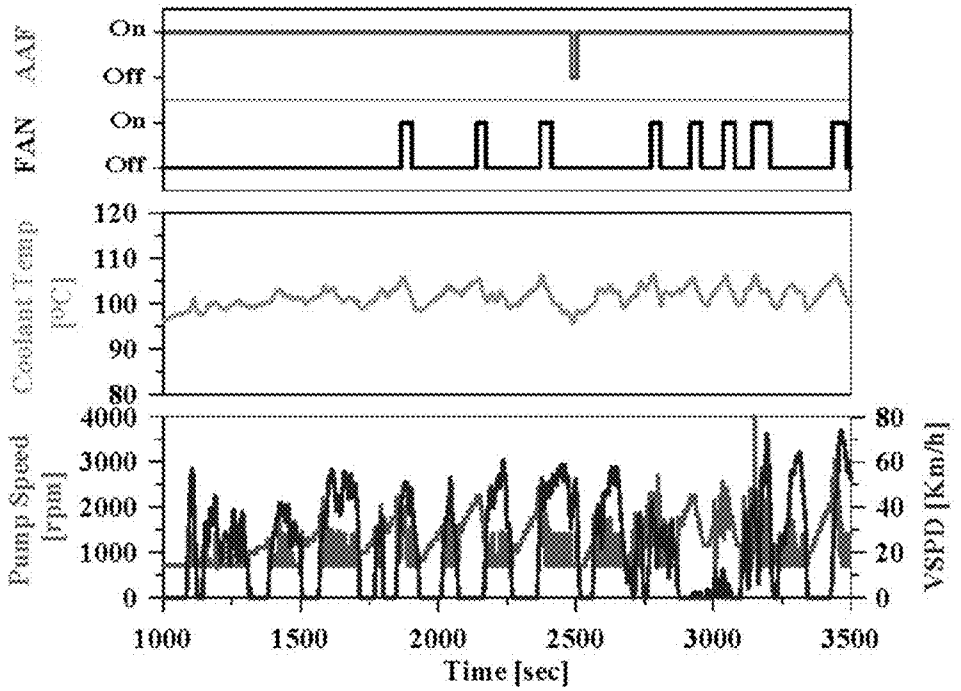

AAF
On
Off
FAN
On
Off
Coolant Temp [℃]
120
110
100
90
80
Pump Speed [rpm]
4000
3000
2000
1000
0
-1000
VSPD [Km/h]
100
80
60
40
20
0
1600
2000
2400
Time [sec]

FIG. 9


AAF
On
Off
FAN
On
Off
Coolant Temp [℃]
120
110
100
90
80
Pump Speed [rpm]
4000
3000
2000
1000
0
VSPD [Km/h]
80
60
40
20
0
1000
1500
2000
2500
3000
3500
Time [sec]

COOLING SYSTEM FOR VEHICLE AND CONTROL METHOD THEREFOR

CROSS-REFERENCE TO RELATED APPLICATION

[0001] The present application claims priority of Korean Patent Application Number 10-2013-0157987 filed on Dec. 18, 2013, the entire contents of which application are incorporated herein for all purposes by this reference.

BACKGROUND OF INVENTION

[0002] 1. Field of Invention

[0003] The present invention relates to a cooling system for a vehicle and a control method therefor, and more particularly, to a cooling system for a vehicle and a control method therefor capable of effectively controlling a cooling amount without a thermostat and/or a control valve, by controlling an introduced air amount and a coolant flow rate passing through a radiator by controlling an air flap apparatus in a vehicle in which the air flap apparatus is equipped.

[0004] 2. Description of Related Art

[0005] As is generally known, as one of the technologies of improving fuel efficiency of a vehicle in a car maker, various researches for cooling a power train system, that is, cooling an engine system have been conducted.

[0006] Among various researches, research and development of an electric cooling system configured by replacing a mechanical water pump with an electric water pump has been frequently made. The reason of replacing the mechanical water pump with the electric water pump is as follows.

[0007] That is, the mechanical water pump is operated in proportion to an engine revolution speed, that is, depending on the engine revolution speed, and thus is operated regardless of a required amount for cooling, which leads to a loss of energy in some sections and exerts a bad influence on fuel efficiency. To prevent the loss, a cooling system using an electric water pump which may be operated by an external control has been researched and developed and applied.

[0008] An example of the existing cooling system using the electric water pump as described above is illustrated in FIGS. **1** to **3**.

[0009] Referring to FIG. **1**, the cooling system is configured by simply replacing a mechanical water pump with an electric water pump **20** in the cooling system using the mechanical water pump. That is, the electric cooling system illustrated in FIG. **1** uses a thermostat **30** applied to the mechanical cooling system as it is. Reference numeral **10** represents an engine, reference numeral **40** represents a radiator, reference numeral **50** represents a heater core, and reference numeral **60** represents a bypass passage.

[0010] The electric cooling system of FIG. **1** has an advantage in that a configuration is simple and the number of parts, which are exchanged at the time of changing the mechanical cooling system to the electric cooling system, is minimized, but has a disadvantage in that a function of the electric water pump may not be sufficiently used.

[0011] Referring to FIGS. **2** and **3**, these cooling systems are configured to include the electric water pump **20** and an electronic control valve **70** which may control a passage.

[0012] In the configuration of FIG. **1**, these cooling systems are a cooling system in which the thermostat is replaced with the electronic control valve **70** which may control the passage, and may implement a high temperature control and a fast cooling control and control the heater core **50** and a flow rate of the bypass passage **60**, but have a complicated configuration.

[0013] A factor to complicate the configuration in each cooling system illustrated in FIGS. **1** to **3** is the thermostat and/or the control valve, but the reason why the thermostat and/or the control valve are not removed is that the cooling amount is controlled by the thermostat and/or the control valve.

[0014] Meanwhile, parts for driving the vehicle, such as an engine, and various heat exchangers such as a radiator, an intercooler, an evaporator, and a condenser are provided inside an engine room of a vehicle is provided, and a heat exchange medium such as a refrigerant flows in the parts and the heat exchange medium inside the heat exchanger and air outside the heat exchanger exchange heat to perform cooling or heat generation.

[0015] Therefore, to stably operate various heat exchangers within the engine room of the vehicle, external air needs to be smoothly supplied to the inside of the engine room, but when a vehicle is driven at high speed, a large amount of external air is introduced into the engine room at high speed, and thus an air resistance is increased.

[0016] As a result, the fuel efficiency of the vehicle may be degraded. To solve the above problem, an air flap apparatus, that is, an active air flap (AAF) apparatus, which may improves fuel efficiency by introducing a relatively larger amount of air into the engine room at the time of driving the vehicle at low speed and introducing a relatively smaller amount of air into the engine room at the time of driving the vehicle at high speed, has been used.

[0017] The information disclosed in this Background section is only for enhancement of understanding of the general background of the invention and should not be taken as an acknowledgement or any form of suggestion that this information forms the prior art already known to a person skilled in the art.

SUMMARY OF INVENTION

[0018] The present invention has been made in an effort to provide a cooling system for a vehicle and a control method therefor capable of effectively controlling a cooling amount without a thermostat and/or a control valve and simplifying a configuration of a cooling system, by controlling an introduced air amount and a coolant flow rate passing through a radiator by controlling an air flap apparatus (or active air flap apparatus) in a vehicle in which the air flap apparatus is equipped.

[0019] Further, the present invention has been made in an effort to provide a cooling system for a vehicle and a control method therefor capable of performing an engine warm-up by controlling a cooling amount using an air flap at the time of cooling.

[0020] Various aspects of the present invention provide a cooling system for a vehicle, including: an electric water pump configured to circulate coolant; an active air flap (AAF) apparatus configured to actively control an air amount introduced into an engine room of the vehicle; a radiator configured to supply the coolant to an engine; a fan configured to cool the coolant of the radiator; and a control unit configured to control the electric water pump, the air flap apparatus, and the fan depending on a driving state and condition of the vehicle, in which the radiator is directly connected to the

electric water pump without a thermostat or a control value being interposed between the radiator and the electric water pump.

[0021] The control unit may control the active air flap apparatus to control a cooling air amount passing through the radiator and control the electric water pump to control a coolant flow rate to keep the coolant at a set coolant temperature.

[0022] A thermostat and an electronic control valve may be removed from the vehicle to which the cooling system is applied.

[0023] The control unit may receive a signal associated with the active air flap apparatus from an active air flap control unit and receive a signal associated with the engine from an engine control unit (ECU).

[0024] Various other aspects of the present invention provide a control method for a cooling system for a vehicle in which an active air flap apparatus is equipped and an electric water pump is directly connected to a radiator, the control method comprising: detecting an engine output, an engine speed, a vehicle speed, and/or a coolant temperature which correspond to a vehicle state; controlling the active air flap apparatus depending on the vehicle state; controlling the electric water pump depending on the vehicle state; and controlling a fan for cooling the coolant of the radiator of the cooling system depending on the vehicle state, in which the controlling of the active air flap apparatus, the controlling of the electric water pump, and the controlling of the fan are integrally combined with each other to keep the coolant at a set temperature.

[0025] The controlling of the active air flap apparatus may include: closing at least one stage of the air flap when the air flap is in a closing control condition; and opening at least one stage of the air flap when the air flap is in an opening control condition.

[0026] The controlling of the electric water pump may include: controlling the electric water pump to a set speed based on an external temperature, the engine output, the vehicle speed, the coolant temperature, and/or an operation state of the air flap, when the electric water pump is in an operation condition.

[0027] The controlling of the fan may include: controlling the fan to a set speed based on an external temperature, the engine output, the vehicle speed, the coolant temperature, and/or operation states of the air flap and the electric water pump, when the fan is in an operation condition.

[0028] The controlling of the air flap apparatus may include: controlling opening and/or closing operations of the air flap based on an external temperature, the engine output, the vehicle speed, the coolant temperature, and/or operation states of the electric water pump and the fan, when the air flap apparatus is in an operation condition.

[0029] As described above, according to various aspects of the present invention, it is possible to effectively control the cooling amount without the thermostat and/or a control valve by controlling the introduced air amount and the coolant flow rate passing through the radiator, by controlling the active air flap apparatus in the vehicle in which the active air flap apparatus is equipped. Further, according to various aspects of the present invention, it is possible to rapidly perform the engine warm-up by controlling the cooling amount using the air flap at the time of cooling.

[0030] The methods and apparatuses of the present invention have other features and advantages which will be apparent from or are set forth in more detail in the accompanying drawings, which are incorporated herein, and the following Detailed Description, which together serve to explain certain principles of the present invention.

BRIEF DESCRIPTION OF THE DRAWINGS

[0031] FIG. **1** is a block configuration diagram of a cooling system for a vehicle according to the related art.

[0032] FIG. **2** is a block configuration diagram of a cooling system for a vehicle according to the related art.

[0033] FIG. **3** is a block configuration diagram of a cooling system for a vehicle according to the related art.

[0034] FIG. **4** is a configuration diagram of an exemplary cooling system for a vehicle according to the present invention.

[0035] FIG. **5** is a flow chart of an exemplary control method for a cooling system for a vehicle according to the present invention.

[0036] FIG. **6** is a diagram illustrating a connection relationship of an exemplary control method for a cooling system for a vehicle according to the present invention.

[0037] FIG. **7** is a graph describing the control system for a vehicle and the control method therefor according to the exemplary embodiment of the present invention.

[0038] FIG. **8** is a graph describing the control system for a vehicle and the control method therefor according to the exemplary embodiment of the present invention.

[0039] FIG. **9** is a graph describing the control system for a vehicle and the control method therefor according to the exemplary embodiment of the present invention.

DETAILED DESCRIPTION

[0040] Reference will now be made in detail to various embodiments of the present invention(s), examples of which are illustrated in the accompanying drawings and described below. While the invention(s) will be described in conjunction with exemplary embodiments, it will be understood that present description is not intended to limit the invention(s) to those exemplary embodiments. On the contrary, the invention (s) is/are intended to cover not only the exemplary embodiments, but also various alternatives, modifications, equivalents and other embodiments, which may be included within the spirit and scope of the invention as defined by the appended claims.

[0041] In the specification and claims, unless explicitly described to the contrary, the word "comprise" and variations such as "comprises" or "comprising", will be understood to imply the inclusion of stated elements but not the exclusion of any other elements. Like reference numerals designate like elements throughout the specification.

[0042] FIG. **4** is a configuration diagram of a cooling system for a vehicle according to various embodiments of the present invention. The cooling system for a vehicle according to various embodiments of the present invention is a system which controls an introduced air amount and a coolant flow rate passing through a radiator by controlling an air flap apparatus in a vehicle in which the air flap apparatus is equipped.

[0043] The cooling system for a vehicle according to various embodiments of the present invention includes: an electric water pump **120** configured to circulate coolant; an active air flap (AAF) apparatus **180** configured to actively control an air amount introduced into an engine room of the vehicle; a

radiator **140** configured to supply coolant to an engine **110**; a cooling fan **145** configured to cool the coolant of the radiator **140**; a heater core **150** configured to heat an interior of the vehicle; and a control unit **200** configured to control the electric water pump **120**, the air flap apparatus **180**, and the fan **145** depending on a driving state and condition of the vehicle.

[0044] As illustrated in FIG. **4**, the radiator **140** is directly connected to the electric water pump **120**, without a thermostat and a control valve, which are essential constituent elements in the existing cooling system, being interposed between the radiator **140** and the electric water pump **120**. Therefore, the vehicle to which the exemplary embodiment of the present invention is applied does not have the thermostat and the electronic control valve.

[0045] The engine **110**, the electric water pump **120**, the air flap apparatus **180**, the fan **145**, and the heater core **150** may each use the existing apparatuses or similar apparatuses, and therefore the detailed description thereof will be omitted.

[0046] The control unit **200** receives a signal associated with the active air flap apparatus **180** from an active air flap (AAF) control unit **280** and receives a signal associated with the engine **110** from an engine control unit (ECU) **210**, but it should be understood that the scope of the present invention is not limited thereto. Even in a different configuration from the above configuration, the technical spirit of the present invention may be applied to any configuration which may substantially receive the signal associated with the active air flap apparatus **180**.

[0047] The control unit **200** controls the active air flap apparatus **180** to control the cooling air amount passing through the radiator **140** and controls the electric water pump **120** to control the coolant flow rate, thereby keeping the set coolant temperature.

[0048] That is, the control unit **200** includes at least one microprocessor which is operated by a set program and/or hardware including the microprocessor, in which the set program may be configured of a series of commands performing a control method for a cooling system for a vehicle according to an exemplary embodiment of the present invention, which will be described below.

[0049] According to various embodiments of the present invention, the control unit **200** is configured alone or may be configured to include the AAF control unit **280** and/or the engine control unit **210** or may be configured to be included in the AAF control unit **280** or the engine control unit **210**, in terms of a design.

[0050] Hereinafter, the control method for a cooling system for a vehicle according to various embodiments of the present invention will be described in detail with reference to the accompanying drawings.

[0051] FIG. **5** is a flow chart of a control method for a cooling system for a vehicle according to various embodiments of the present invention, and FIG. **6** is a diagram illustrating a connection relationship of the control method for a cooling system for a vehicle according to various embodiments of the present invention.

[0052] As illustrated, the control unit **200** is, for example, keyed on and thus starts when the vehicle starts to drive, such that the control unit **200** detects an engine output, an engine speed, a vehicle speed, a coolant temperature, or the like which correspond to the vehicle state (S**100**).

[0053] The control unit **200** may receive the engine output, the engine speed, the vehicle speed, the coolant temperature, or the like from the engine control unit **210** and the engine control unit **210** generally detects and uses information and/or data as described above, and therefore the detailed description thereof will be omitted.

[0054] When the engine output, the engine speed, the vehicle speed, the coolant temperature, or the like corresponding to the vehicle state are received from the engine control unit **210**, the control unit **200** organically performs controlling an active air flap control (S**200**), controlling an electric water pump (S**300**), and controlling a fan (S**400**) based on the engine output, the engine speed, the vehicle speed, the coolant temperature, or the like, as illustrated in FIG. **6**.

[0055] That is, the control unit **200** organically or integrally or systematically performs controlling the active air flap apparatus **180** depending on the vehicle state (S**200**); controlling the electric water pump **120** depending on the vehicle state (S**300**); and controlling the fan **145** for cooling the coolant of the radiator **140** of the cooling system depending on the vehicle state (S**400**), thereby keeping the temperature of the coolant at the set temperature.

[0056] Hereinafter, the controlling of the active air flap (S**200**), the controlling of the electric water pump (S**300**), and the controlling of the fan (S**400**) will be described in detail.

[0057] First, when the AAF is in an operation condition (S**210**), the control unit **200** controls closing and/or opening operation of the air flap based on the external temperature, the engine output, the vehicle speed, the coolant temperature, and/or the operation states of the electric water pump **120** and the fan **145**. The operation condition of the AAF may depend on the existing operation condition.

[0058] That is, when the air flap is in a closing control condition (S**220**), the control unit **200** performs an AAF closing control (S**250**), or otherwise determines whether the AAF is in the opening condition (S**230**). In step S**250**, when a stage number of the air flap is configured in plural, for example, when the air flap is configured of two stages, that is, an upper stage and a lower stage, the upper stage control and the lower stage control may be separately performed.

[0059] In step S**230**, when the AAF is not in the opening condition, the control unit **200** performs the AAF opening control (S**240**). Even in step S**240**, the upper stage control and the lower stage control of the air flap may be separately performed.

[0060] Further, when the electric water pump **120** is in an operation condition (S**310**), the control unit **200** controls the electric water pump **120** at the set speed based on the external temperature, the engine output, the vehicle speed, the coolant temperature, and/or the operation states of the air flap apparatus **180** and the fan **145** ((S**320**), (S**330**), and (S**340**)). The operation condition of the electric water pump may depend on the existing operation condition.

[0061] In addition, when the fan **145** is in an operation condition (S**410**), the control unit **200** controls the fan **145** to a set speed based on the external temperature, the engine output, the vehicle speed, the coolant temperature, and the operation states of the air flap apparatus **180** and the electric water pump **120**. The operation condition of the fan may depend on the existing operation condition.

[0062] That is, when the fan is in a one-stage operation condition (S**420**), the control unit **200** controls the speed of the fan **145** at a one stage (S**425**), when the fan is in a two-stage operation condition (S**430**), controls the speed of

the fan **145** at a two stage (S**435**), and when the fan is in a non-operation condition, stops the fan **145** (S**445**).

[0063] As the result, according to various embodiments of the present invention, it is possible to effectively control the cooling amount without the thermostat and/or a control valve and simplifying the configuration of the cooling system, by controlling the introduced air amount and the coolant flow rate passing through the radiator by controlling the active air flap apparatus in the vehicle in which the active air flap apparatus is equipped.

[0064] For convenience in explanation and accurate definition in the appended claims, the terms "upper" or "lower", "inside" or "outside", and etc. are used to describe features of the exemplary embodiments with reference to the positions of such features as displayed in the figures.

[0065] The foregoing descriptions of specific exemplary embodiments of the present invention have been presented for purposes of illustration and description. They are not intended to be exhaustive or to limit the invention to the precise forms disclosed, and obviously many modifications and variations are possible in light of the above teachings. The exemplary embodiments were chosen and described in order to explain certain principles of the invention and their practical application, to thereby enable others skilled in the art to make and utilize various exemplary embodiments of the present invention, as well as various alternatives and modifications thereof. It is intended that the scope of the invention be defined by the Claims appended hereto and their equivalents.

What is claimed is:

1. A cooling system for a vehicle, comprising:
- an electric water pump configured to circulate a coolant;
- an air flap apparatus configured to actively control an air amount introduced into an engine room of the vehicle;
- a radiator configured to supply the coolant to an engine;
- a fan configured to cool the coolant of the radiator; and
- a control unit configured to control the electric water pump, the air flap apparatus, and the fan depending on a driving state and condition of the vehicle,
- wherein the radiator is directly connected to the electric water pump without a thermostat or a control value being interposed between the radiator and the electric water pump.

2. The system of claim **1**, wherein:
- the thermostat and/or the electronic control valve are removed from the vehicle to which the cooling system is applied.

3. The system of claim **1**, wherein:
- the control unit receives a signal associated with the air flap apparatus from an air flap control unit and receives a signal associated with the engine from an engine control unit (ECU).

4. The system of claim **3**, wherein:
- the control unit controls the air flap apparatus to control a cooling air amount passing through the radiator and controls the electric water pump to control a coolant flow rate to keep the coolant at a set coolant temperature.

5. A control method for a cooling system for a vehicle in which an air flap apparatus is equipped and an electric water pump is directly connected to a radiator, the control method comprising:
- detecting an engine output, an engine speed, a vehicle speed, and/or a coolant temperature which correspond to a vehicle state;
- controlling the air flap apparatus depending on the vehicle state;
- controlling the electric water pump depending on the vehicle state; and
- controlling a fan for cooling the coolant of the radiator of the cooling system depending on the vehicle state,
- wherein the controlling of the air flap apparatus, the controlling of the electric water pump, and the controlling of the fan are integrally combined with each other to keep the coolant at a set temperature.

6. The method of claim **5**, wherein the controlling of the air flap apparatus includes:
- closing at least one stage of the air flap when the air flap is in a closing control condition; and
- opening at least one stage of the air flap when the air flap is in an opening control condition.

7. The method of claim **5**, wherein the controlling of the electric water pump includes:
- controlling the electric water pump to a set speed based on an external temperature, the engine output, the vehicle speed, the coolant temperature, and/or an operation state of the air flap, when the electric water pump is in an operation condition.

8. The method of claim **5**, wherein the controlling of the fan includes:
- controlling the fan to a set speed based on an external temperature, the engine output, the vehicle speed, the coolant temperature, and/or operation states of the air flap and the electric water pump, when the fan is in an operation condition.

9. The method of claim **5**, wherein the controlling of the air flap apparatus includes:
- controlling opening and/or closing operations of the air flap based on an external temperature, the engine output, the vehicle speed, the coolant temperature, and/or operation states of the electric water pump and the fan, when the air flap apparatus is in an operation condition.

* * * * *