ACTIVE GRILLE SHUTTER

Applicant: Fuji Jukogyo Kabushiki Kaisha, Tokyo (JP)

Inventors: Keishi Numata, Tokyo (JP); Seiji Kawaguchi, Tokyo (JP); Gentaro Hatanaka, Tokyo (JP); Kazuhiro Hayakawa, Tokyo (JP); Eiji Fuji, Tokyo (JP); Hirotoke Nishina, Tokyo (JP); Shinji Fukushima, Tokyo (JP)

Assignee: Fuji Jukogyo Kabushiki Kaisha, Tokyo (JP)

Appl. No.: 14/226,655

Filed: Mar. 26, 2014

Foreign Application Priority Data
Mar. 28, 2013 (JP) ......................... 2013-069052

Publication Classification

Int. Cl.
F01P 7/10 (2006.01)

U.S. Cl.
CPC ........................................ F01P 7/10 (2013.01)
USPC ......................................... 123/41.05

ABSTRACT

An active grille shutter controls opening and closing of a variable duct device which uses movable louvers to open and close an opening provided at the front end of a vehicle to introduce moving air. The active grille shutter includes: thermal load state detection units each configured to detect a thermal load state of the vehicle; and an opening and closing control unit configured to set the variable duct device in a closed state in a normal condition, and to set the variable duct device in an open state when it is determined that the thermal load state of the vehicle is a predetermined high thermal load state.
FIG. 4

START

S01

ABNORMALITY IS DETECTED IN RELATED SYSTEM? YES

NO

S02

AMBIENT TEMPERATURE IS LOWER THAN OR EQUAL TO LOW TEMPERATURE THRESHOLD VALUE? YES

NO

S03

VEHICLE SPEED IS LOW? YES

NO

S04

ENGINE IS IN HIGH LOAD STATE? YES

NO

S05

ONE OF OIL TEMPERATURE AND COOLANT TEMPERATURE IS IN HIGH STATE? YES

NO

S06

AMBIENT TEMPERATURE IS HIGHER THAN OR EQUAL TO HIGH TEMPERATURE THRESHOLD VALUE? YES

NO

S07

A/C IS IN HIGH LOAD? YES

NO

S08

CLOSE VARIABLE DUCT

END

S09

OPEN VARIABLE DUCT
ACTIVE GRILLE SHUTTER
CROSS-REFERENCE TO RELATED APPLICATIONS

The present application claims priority from Japanese Patent Application No. 2013-069052 filed on Mar. 28, 2013, the entire contents of which are hereby incorporated by reference.

BACKGROUND

1. Technical Field

The present invention relates to an active grille shutter for controlling opening and closing of a variable duct, and particularly to an active grille shutter that is capable of properly controlling opening and closing of a variable duct disposed in an opening of the bumper face at the front end of a vehicle.

2. Related Art

In a vehicle such as an automobile, moving air for cooling is introduced through an opening to cool components such as a radiator, a capacitor of an air conditioner, and an intercooler, the opening being provided in a bumper face at the front end of the vehicle. In recent years, there has been known a technology using an openable and closeable variable duct (active grille shutter) which is provided in such an opening. In the technology, when a cooling load is low and so a small amount of moving air is sufficient, the variable duct is closed, thereby reducing air resistance and improving fuel efficiency.

A conventional technology related to such a variable duct is described in, for example, Japanese Unexamined Patent Application Publication (JP-A) No. 2007-1503. In JP-A No. 2007-1503, a variable duct (variable grille shutter device) is mounted immediately forward of the radiator in the vicinity of the front end of the engine compartment.

In order to further enhance fuel efficiency improvement effect due to an improvement in the aerodynamic performance of the above-described variable duct device, it is preferable that the frequency of the occurrence of the closed state should be increased as much as possible, and an open state should occur only when it is highly necessary to introduce moving air. In addition, at an extremely low temperature which may cause freezing problem, a forced operation of opening or closing may damage components, and when fixation occurs in an open state, excessive cooling may occur.

SUMMARY OF THE INVENTION

An object of the present invention is to provide an active grille shutter which is capable of properly controlling opening and closing of a variable duct.

A first aspect of the invention provides an active grille shutter for controlling opening and closing of a variable duct device that uses a movable lower to open and close an opening provided at a front end of a vehicle to introduce air, the active grille shutter including: a thermal load state detection unit configured to detect a thermal load state of the vehicle; and an opening and closing control unit configured to set the variable duct device in a closed state in a normal condition, and to set the variable duct device in an open state when it is determined that the thermal load state of the vehicle is a predetermined high thermal load state.

The thermal load state detection unit may include an ambient temperature sensor configured to detect an ambient temperature, and the opening and closing control unit may be configured to maintain the variable duct device in a closed state irrespective of a result of the detection by the thermal load state detection unit when the ambient temperature is substantially below a freezing point.

The thermal load state detection unit may include a vehicle speed sensor configured to detect a running speed of the vehicle, and the opening and closing control unit may be configured to determine that the vehicle is in the high thermal load state when the vehicle has a low running speed which is lower than or equal to a predetermined value.

The thermal load state detection unit may include an engine output state detection unit configured to detect an output state of an engine, and the opening and closing control unit may be configured to determine that the vehicle is in the high thermal load state when the engine is in a predetermined high output state.

The thermal load state detection unit may include a temperature sensor configured to detect at least either one of a coolant temperature and a lubricating oil temperature of the engine, and the opening and closing control unit may be configured to determine that the vehicle is in the high thermal load state when the at least either one of the coolant temperature and the lubricating oil temperature is higher than or equal to a predetermined value.

The thermal load state detection unit may include an ambient temperature sensor configured to detect an ambient temperature, and the opening and closing control unit may be configured to determine that the vehicle is in the high thermal load state when the ambient temperature is in a predetermined high temperature state.

The thermal load state detection unit may include an air conditioner state detection unit configured to detect an operational state of an air conditioner, and the opening and closing control unit may be configured to determine that the vehicle is in the high thermal load state when the operational state of the air conditioner is in a predetermined high load state.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a schematic cross-sectional view of the front end of a vehicle having an implementation of an active grille shutter according to the present invention, the view being taken along a vertical plane in the middle of the width of the vehicle before a collision and in a closed state of a variable duct;

FIG. 2 is an enlarged view of portion II in FIG. 1;

FIG. 3 is a block diagram illustrating a configuration of an active grille shutter in the implementation; and

FIG. 4 is a flow chart illustrating the opening and closing control by the active grille shutter in the implementation.

DETAILED DESCRIPTION

[Implementation]

Hereinafter, an implementation of an active grille shutter according to the present invention will be described. The active grille shutter in the implementation controls a variable duct device which substantially opens and closes, for example, an air dam opening provided at the front end of an automobile such as a passenger car. FIG. 1 is a schematic cross-sectional view of the front end of a vehicle having the
active grille shutter in the implementation, the view being taken along a vertical plane in the middle of the width of the vehicle before a collision and in a closed state of a variable duct. FIG. 2 is an enlarged view of portion II in FIG. 1.

[0021] The front of the vehicle includes a bumper face 10, a bumper beam 20, a radiator 30, a capacitor 40, a radiator panel 50, an energy absorbing material (EA material) 60, and a variable duct 100.

[0022] The bumper face 10 is an exterior member provided at the front end of the vehicle, and is integrally formed of, for example, a resin material such as PP. The bumper face 10 includes a main body 11 and an air dam 12. The main body 11 is disposed under a front grille and a head lamp which are not illustrated. The air dam 12 is disposed to be spaced apart from and under the main body 11. An opening O for introducing moving air for cooling is provided between the main body 11 and the air dam 12.

[0023] The main body 11 includes a front surface portion 11a, an upper surface portion 11b, and a lower surface portion 11c. The front surface portion 11a is a surface portion which is disposed substantially parallel to the vertical direction at the front of the vehicle. The upper surface portion 11b is a surface portion which is disposed to extend rearwardly from the upper end of the front surface portion 11a. The lower surface portion 11c is a surface portion which is disposed substantially in the horizontal direction, and the upper end of the variable duct 100 is fixed to the lower surface portion 11c.

[0024] The air dam 12 includes a front surface portion 12a, an upper surface portion 12b, and a lower surface portion 12c. The front surface portion 12a is a surface portion which is disposed substantially parallel to the vertical direction at the front of the vehicle. The upper surface portion 12b is a surface portion which is disposed to extend rearwardly from the upper end of the front surface portion 12a, and the lower end of the variable duct 100 is fixed to the upper surface portion 12b. The lower surface unit 12c is a surface portion which is disposed to extend rearwardly from the lower end of the front surface portion 12a.

[0025] The bumper beam 20 is a beam-shaped member which is disposed at the rear of the main body 11 and extends substantially in the width direction of the vehicle. The bumper beam 20 has a substantially rectangular closed cross-section.

[0026] The radiator 30 cools a coolant (not illustrated) of the engine by heat exchange with moving air. The radiator 30 is formed by disposing a great number of fins around a tube through which the coolant flows.

[0027] The capacitor 40 cools vapor phase cooling medium of an air conditioner (not illustrated) by heat exchange with moving air, and the cooling medium condenses to liquid phase. The capacitor 40 is formed by disposing a great number of fins around a tube through which the cooling medium flows. The capacitor 40 is disposed forwardly of the radiator 30.

[0028] The radiator panel 50 is a frame-shaped vehicle structural member which is disposed around the radiator 30 and the capacitor 40 to support the radiator 30 and the capacitor 40. A radiator panel lower 51 is disposed at the lower end of the radiator panel 50. The radiator panel lower 51 is formed of a pair of sheet metal panels with a hollow therebetween so as to have a closed cross-section.

[0029] The EA material 60 is disposed rearwardly of the air dam 12 configured to absorb a load inputted from the air dam 12 at the time of a collision and to transmit the load to the vehicle body. The EA material 60 is formed by connecting a plurality of ribs with an upper surface, the ribs being arranged in the fore-and-aft direction of the vehicle and extending substantially in the vertical direction. The EA material 60 is integrally formed of, for example, a resin material. The front end of the EA material 60 is inserted into the inside of the air dam 12, and an upper portion of the EA material 60 is disposed under the radiator panel 50.

[0030] The variable duct 100 is provided in the opening O of the bumper face 10 and configured to substantially open and close the opening O. The variable duct 100 has a frame body 110, an upper louver 120, and a lower louver 130. In addition, the variable duct 100 has a control device illustrated in FIG. 3. FIG. 3 is a block diagram illustrating the configuration of the active grille shutter in the implementation. As illustrated in FIG. 3, the variable duct 100 includes an actuator 140 and a variable grille shutter 150 which controls the actuator 140.

[0031] The frame body 110 is disposed along the inner peripheral edge of the opening O of the bumper face 10 so as to have a substantially rectangular view as seen from a forward position of the vehicle. An upper edge 111 of the frame body 110 is fixed to the underside of a rear end portion of the lower surface portion 11c of the main body 11 of the bumper face 10. The upper edge 111 is disposed substantially in a horizontal direction, and forms a plate-like strip extending substantially in the vehicle width direction. The rear end of the upper edge 111 has a projection portion 111a (see FIG. 2) which projects downward. When the upper louver 120 is in a closed state, the projection portion 111a is in contact with the rear surface of an upper end portion of an upper half 122 of the upper louver 120. A lower edge 112 of the frame body 110 is fixed to the top surface of a rear end portion of the upper surface portion 12b of the air dam 12 of the bumper face 10. When the lower louver 130 is in a closed state in which the lower louver 130 is placed substantially parallel to the vertical direction, the rear end of the lower edge 112 is in contact with the front surface of a lower end portion of a lower half 133 of the lower louver 130. The upper surface of the lower edge 112 is formed as an inclined surface which is inclined downward toward the front of the vehicle.

[0032] The upper louver 120 and the lower louver 130 aremovable louvers which are rotated around respective rotation shafts extending in the vehicle width direction so as to open and close the inside of the frame body 110. The upper louver 120 and the lower louver 130 are capable of closing the upper half and the lower half of the frame body 110, respectively. As illustrated in FIG. 2, in a closed state, the upper louver 120 has the fin-shaped upper half 122 which projects upward from a rotation shaft 121, and the fin-shaped lower half 123 which projects downward from the rotation shaft 121. Similarly, in an open state, the lower louver 130 has a fin-shaped upper half 132 which projects upward from a rotation shaft 131, and the fin-shaped lower half 133 which projects downward from the rotation shaft 131. The rotation shaft 121 of the upper louver 120 and the rotation shaft 131 of the lower louver 130 are disposed to be spaced apart in the vertical direction. When the variable duct 100 is in a closed state, a lower end portion of the lower half 123 of the upper louver 120 is in contact with an upper end portion of the upper half 122 of the lower louver 130.

[0033] As illustrated by the solid line in FIG. 2, when the upper halves 122, 132, and the lower halves 123 and 133 are
placed substantially parallel to the vertical direction, the inside of the frame body 110 is substantially closed (closed state). As illustrated by the dashed line in FIG. 2, the upper louver 120 and the lower louver 130 are rotated around the rotation shafts 121 and 131 in a direction in which the upper halves 122 and 132 move forward, respectively, thereby allowing moving air to flow through the inside of the frame body 110 (opened state).

In the upper louver 120, the amount of projection of the upper half 122 from the rotation shaft 121 is made to be smaller than the amount of projection of the lower half 123 from the rotation shaft 121. Consequently, when the upper louver 120 is in a closed state, the height of the rotation shaft 121 is located offset upward from the center of the upper louver 120. With the above configuration, the upper louver 120 in a closed state allows moving air pressure to generate a moment of rotation of the upper louver 120 to an open state position. On the other hand, in the lower louver 130, the amounts of projection of the upper half 132 and the lower half 133 from the rotation shaft 131 are substantially equal.

The actuator 140 is a power source for opening and closing the variable duct 100. The actuator 140 includes, for example, an electric motor and a reduction gear train for decelerating the output of the electric motor. The actuator 140 drives a driven gear (not illustrated) which is mounted on the lateral side of the upper louver 120. Although the upper louver 120 is interlocked with the upper louver 120 via a linkage mechanism (not illustrated), when the upper louver 120 is rotatable and fixation occurs in the lower louver 130, only the upper louver 120 is opened or closed by deforming a flexible member provided in the linkage mechanism.

The active grille shutter 150 controls the actuator 140 to open and close the variable duct 100, and serves as the opening and closing control unit according to the present invention. The active grille shutter 150 includes an information processing device such as a CPU, a storage device such as a RAM or a ROM, an input/output interface, and a bus for connecting these devices.

The active grille shutter 150 is connected to an engine control unit 210, a behavior control unit 220, and a vehicle integration unit 230 via, for example, a CAN communication system which is a type of in-vehicle LAN.

The engine control unit 210 comprehensively controls the engine and its auxiliary devices, the engine being a power source for running the vehicle. The engine control unit 210 is connected to an oil temperature sensor 211, a coolant temperature sensor 212, and a fuel supply device 213.

The oil temperature sensor 211 detects a temperature of lubricating oil for the engine. The coolant temperature sensor 212 detects a temperature of coolant for the engine. The fuel supply device 213 supplies fuel to the engine, and includes an injector for injecting fuel into a combustion chamber or a port of each of cylinders, the fuel being pressurized by a fuel pump. The engine control unit 210 can detect the amount of fuel supplied to the engine based on a valve open time of the injector in the fuel supply device 213.

The behavior control unit 220 performs behavior control and/or anti-lock brake control when behavior such as oversteer or understeer occurs in the vehicle, the behavior control generating a yaw moment in a direction for inhibiting the behavior by applying different braking forces to the right and left wheels. The behavior control unit 220 is connected to a vehicle speed sensor 221. The vehicle speed sensor 221 outputs a vehicle speed pulse signal according to the revolution speed of wheels.

The vehicle integration unit 230 comprehensively controls various electric equipment of the vehicle. The vehicle integration unit 230 is connected to an air conditioner (A/C) control unit 231 and an ambient temperature sensor 232. The air conditioner control unit 231 controls an air conditioner for cabin air conditioning. The air conditioner control unit 231 is capable of determining the operating load of the air conditioner based on factors including a cooling medium temperature and a cooling medium pressure. The ambient temperature sensor 232 detects an ambient temperature.

Hereinafter, the opening and closing control of the variable duct device in the present implementation will be described. FIG. 4 is a flow chart illustrating the opening and closing control by the active grille shutter in the implementation. Hereinafter, description will be given for each step sequentially.

<Step S01: Related System Abnormality Determination>

The active grille shutter 150 diagnoses whether each sensor or the communication system has an abnormality, and when an abnormality is detected, the flow proceeds to step S09 in order to prevent occurrence of heat damage and overheat. When any of each sensor and the communication system are determined to be normal, the flow proceeds to step S02.

<Step S02: Low Ambient Temperature Determination>

The active grille shutter 150 determines whether or not the ambient temperature detected by the ambient temperature sensor 232 is lower than or equal to a low temperature threshold value (for example, 0°C) which has been set in consideration of an occurrence of freezing of exterior parts. When the ambient temperature is lower than or equal to the low temperature threshold value, the flow proceeds to step S08, otherwise the flow proceeds to step S03.

<Step S03: Low Vehicle Speed Determination>

The active grille shutter 150 compares the current vehicle speed with a threshold value which has been set for determining whether the current vehicle speed causes sufficient moving air. When the vehicle is in a low speed state in which the vehicle speed is lower than or equal to the threshold value, the flow proceeds to step S09, otherwise the flow proceeds to step S04.

<Step S04: Engine Load State Determination>

The active grille shutter 150 determines whether or not the operational state of the engine is a predetermined high load state. For example, when the amount of fuel supplied to the engine by the fuel supply device 213 is greater than or equal to a predetermined threshold value, the operational state is determined to be a high load state. When the operational state of the engine is in a high load state, the flow proceeds to step S09, otherwise, the flow proceeds to step S05.
The active grille shutter 150 compares the lubricating oil temperature and the coolant temperature of the engine with respective threshold values. When at least one of the temperatures is higher than a corresponding threshold value, the vehicle is in a high temperature state and the flow proceeds to step S09, otherwise, the flow proceeds to step S06.

The active grille shutter 150 determines whether or not the ambient temperature detected by the ambient temperature sensor 232 is higher than or equal to a predetermined high temperature threshold value. When the ambient temperature is higher than or equal to the high temperature threshold value, the flow proceeds to step S09. The high temperature threshold value is set to be higher than the low temperature threshold value in consideration of, for example, the daytime ambient temperature in summer. When the ambient temperature is lower than the high temperature threshold value, the flow proceeds to step S07.

When it is determined by the air conditioner control unit 231 that the operational state of the air conditioner is in a high load state, the operational flow of the active grille shutter 150 proceeds to step S09, otherwise, the flow proceeds to step S08.

The active grille shutter 150 outputs a control signal to the actuator 140 to set the variable duct 100 in a closed state. Subsequently, a series of processes is terminated (returned).

The active grille shutter 150 outputs a control signal to the actuator 140 to set the variable duct 100 in an open state. Subsequently, a series of processes is terminated (returned).

With the implementation described above, the following effects can be obtained.

1. The variable duct 100 is maintained to be in a closed state in normal conditions and to be in an open state only when the thermal load state in the engine compartment is a predetermined high load state, and thus a fuel efficiency improvement effect due to an improvement in aerodynamic performance can be obtained in wide operating conditions.

2. When the ambient temperature is in a low temperature state which may cause freezing, the variable duct 100 is maintained to be in a closed state, thereby preventing excessive cooling and damage of parts which may be caused by enforced driving of the vehicle in a freeze state. In addition, a warm temperature promoting effect also can be improved.

3. When the vehicle runs at a low speed at which sufficient moving air is not obtained, the variable duct 100 is set in an open state, thereby increasing the amount of moving air usable for cooling and preventing heat damage and over-heat.

When the engine is in a high load state, or the engine oil temperature or the coolant temperature is high, the variable duct 100 is set in an open state, thereby preventing over-heat.

When the capability of a cooling system may be insufficient due to a high ambient temperature, the variable duct 100 is set in an open state, thereby maintaining the cooling performance.

When thermal load in the engine compartment is high due to high load operation of the air conditioner, the variable duct 100 is set in an open state, thereby preventing heat damage and over-heat and maintaining the performance of the air conditioner.

The present invention is not limited to the above-described implementation and various modifications and alterations may be made, and the modified or altered implementations are also in the technical scope of the present invention. The shape, structure, material quality, manufacturing method, arrangement, and amount of each member included in the support structure for the variable duct are not limited to those in the above-described implementation, and may be changed as needed. In the implementation, the movable louver has two segments. Alternatively, the movable louver may have three or more segments. In the implementation, only the upper louver has a configuration in which the rotation shaft is offset. Alternatively, other louver may have an offset configuration similarly. In addition, parameters used for opening and closing control are not limited to those in the implementation. For example, in the implementation, an output state of the engine is determined based on the amount of fuel injection. Alternatively, other parameters such as an inlet pipe pressure, a throttle position, a boost pressure, a number of revolutions of the engine, and an estimated output torque may be used independently or in combination.

1. An active grille shutter for controlling opening and closing of a variable duct device that uses a movable louvers to open and close an opening provided at a front end of a vehicle to introduce air, the active grille shutter comprising: a thermal load state detection unit configured to detect a thermal load state of the vehicle; and an opening and closing control unit configured to set the variable duct device in a closed state in a normal condition, and to set the variable duct device in an open state when it is determined that the thermal load state of the vehicle is a predetermined high thermal load state.

2. The active grille shutter according to claim 1, wherein the thermal load state detection unit includes an ambient temperature sensor configured to detect an ambient temperature, and the opening and closing control unit is configured to maintain the variable duct device in a closed state irrespective of a result of the detection by the thermal load state detection unit when the ambient temperature is substantially below a freezing point.

3. The active grille shutter according to claim 1, wherein the thermal load state detection unit includes a vehicle speed sensor configured to detect a running speed of the vehicle, and the opening and closing control unit is configured to determine that the vehicle is in the high thermal load state when the vehicle has a low running speed which is lower than or equal to a predetermined value.
4. The active grille shutter according to claim 2, wherein the thermal load state detection unit includes a vehicle speed sensor configured to detect a running speed of the vehicle, and the opening and closing control unit is configured to determine that the vehicle is in the high thermal load state when the vehicle has a low running speed which is lower than or equal to a predetermined value.

5. The active grille shutter according to claim 1, wherein the thermal load state detection unit includes an engine output state detection unit configured to detect an output state of an engine, and the opening and closing control unit is configured to determine that the vehicle is in the high thermal load state when the engine is in a predetermined high output state.

6. The active grille shutter according to claim 2, wherein the thermal load state detection unit includes an engine output state detection unit configured to detect an output state of an engine, and the opening and closing control unit is configured to determine that the vehicle is in the high thermal load state when the engine is in a predetermined high output state.

7. The active grille shutter according to claim 1, wherein the thermal load state detection unit includes a temperature sensor configured to detect at least either one of a coolant temperature and a lubricating oil temperature of the engine, and the opening and closing control unit is configured to determine that the vehicle is in the high thermal load state when the at least either one of the coolant temperature and the lubricating oil temperature is higher than or equal to a predetermined value.

8. The active grille shutter according to claim 2, wherein the thermal load state detection unit includes a temperature sensor configured to detect at least either one of a coolant temperature and a lubricating oil temperature of the engine, and the opening and closing control unit is configured to determine that the vehicle is in the high thermal load state when the at least either one of the coolant temperature and the lubricating oil temperature is higher than or equal to a predetermined value.

9. The active grille shutter according to claim 1, wherein the thermal load state detection unit includes an ambient temperature sensor configured to detect an ambient temperature, and the opening and closing control unit is configured to determine that the vehicle is in the high thermal load state when the ambient temperature is in a predetermined high temperature state.

10. The active grille shutter according to claim 2, wherein the thermal load state detection unit includes an ambient temperature sensor configured to detect an ambient temperature, and the opening and closing control unit is configured to determine that the vehicle is in the high thermal load state when the ambient temperature is in a predetermined high temperature state.

11. The active grille shutter according to claim 1, wherein the thermal load state detection unit includes an air conditioner state detection unit configured to detect an operational state of an air conditioner, and the opening and closing control unit is configured to determine that the vehicle is in the high thermal load state when the operational state of the air conditioner is in a predetermined high load state.

12. The active grille shutter according to claim 2, wherein the thermal load state detection unit includes an air conditioner state detection unit configured to detect an operational state of an air conditioner, and the opening and closing control unit is configured to determine that the vehicle is in the high thermal load state when the operational state of the air conditioner is in a predetermined high load state.