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Braking device for vehicle and braking method therefor

Abstract

The present disclosure provides a braking method of a vehicle, comprising: a control start determination operation of determining whether traction control system (TCS) control is needed; a required pressure calculation operation of calculating required pressures, which are required for wheel brakes to brake a vehicle, of wheels when it is determined that the TCS control is needed; a control mode determination operation of determining whether the TCS control is performed in a single wheel control mode or multi-wheel control mode; and a hydraulic pressure supply operation of supplying hydraulic pressure to a low-pressure wheel brake through valve control and supplying hydraulic pressure to a high-pressure wheel brake through pressure control in the multi-wheel control mode and supplying hydraulic pressure to any one wheel brake through the valve control in the single wheel control mode in order for the wheel brakes to reach the required pressures.

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Background/Summary

CROSS-REFERENCE TO RELATED APPLICATIONS

(1) This application claims priority to and the benefit of Korean Patent Application No. 10-2020-0164135, filed on Nov. 30, 2020, the disclosure of which is incorporated herein by reference in its entirety.

BACKGROUND OF THE INVENTION

1. Field of the Invention

(2) The present disclosure relates to a braking device for a vehicle and a braking method of a vehicle.

2. Discussion of Related Art

(3) The contents described here provide only background information and do not constitute the related art.

(4) Generally, in an electro-hydraulic brake system, a pedal pressure of a driver is detected by a sensor, and a braking pressure of each wheel is adjusted using a hydraulic modulator. The electro-hydraulic brake system includes the sensor, a pedal simulator, and an electronic control unit. The sensor detects a stroke distance of a pedal to allow the driver to recognize a desired braking pressure, and the pedal simulator allows the driver to feel the pedal pressure like a general hydraulic brake system. The electronic control unit determines a desired braking force of the driver through a pedal stroke sensor, a pressure sensor, and the like and drives an additional wheel brake mechanism to generate a braking force in a wheel brake.

(5) The wheel brake mechanism generally includes a main master cylinder structure for generating hydraulic pressure and a hydraulic circuit and a plurality of valves for transmitting the hydraulic pressure generated by the main master to the wheel brake of a vehicle

(6) Methods of controlling traction control system (TCS) in a wheel brake mechanism are used in a single wheel control mode and a multi-wheel control mode. In the single wheel control mode, since hydraulic pressure is generated in only one wheel brake, the wheel brake is controlled in a method similar to a method of combined brake system (CBS) control.

(7) However, in the multi-wheel control mode, different hydraulic pressures should be provided to two or more wheel brakes, the hydraulic pressures of the wheel brakes are controlled using inlet valves and outlet valves connected to the wheel brakes. When a vehicle starts from a stopped state through TCS multi-wheel control, there are problems in that a great deal of noise is generated when the outlet valve operates, a high duty ratio is required when a plurality of solenoid valves operate, and current consumption is high.

BRIEF SUMMARY OF THE INVENTION

(8) The present disclosure is mainly directed to decreasing noise when an outlet valve operates by maintaining a state in which an inlet valve connected to a high-pressure wheel brake is open and controlling an inlet valve and an outlet valve connected to a low-pressure wheel brake in a multi-wheel control mode.

(9) In addition, the present disclosure is also mainly directed to decreasing current consumption in a hydraulic circuit by minimizing the number of solenoid valves to which a current is supplied in a multi-wheel control mode.

(10) According to at least one aspect, the present disclosure provides a braking method of a vehicle, comprising: a control start determination operation of determining whether traction control system (TCS) control is needed; a required pressure calculation operation of calculating required pressures, which are required for wheel brakes to brake a vehicle, of wheels when it is determined that the

TCS control is needed; a control mode determination operation of determining whether the TCS control is performed in a single wheel control mode or multi-wheel control mode; and a hydraulic pressure supply operation of supplying hydraulic pressure to a low-pressure wheel brake through valve control and supplying hydraulic pressure to a high-pressure wheel brake through pressure control in the multi-wheel control mode and supplying hydraulic pressure to any one wheel brake through the valve control in the single wheel control mode in order for the wheel brakes to reach the required pressures.

(11) According to the present embodiment described above, there is an effect of decreasing noise when an outlet valve operates by maintaining a state in which an inlet valve connected to a high-pressure wheel brake is open and controlling an inlet valve and an outlet valve connected to a low-pressure wheel brake in a multi-wheel control mode.

(12) In addition, there is an effect of decreasing current consumption in a hydraulic circuit by minimizing the number of solenoid valves to which a current is supplied in a multi-wheel control mode.

Description

BRIEF DESCRIPTION OF THE DRAWINGS

- (1) The above and other objects, features and advantages of the present disclosure will become more apparent to those of ordinary skill in the art by describing exemplary embodiments thereof in detail with reference to the accompanying drawings, in which:
- (2) FIG. 1 is a hydraulic circuit diagram illustrating a braking device according to one embodiment of the present disclosure;
- (3) FIG. 2 is a hydraulic circuit diagram illustrating a flow of a brake fluid in order for an electronic control unit according to one embodiment of the present disclosure to increase or decrease a pressure in the hydraulic circuit in a traction control system (TCS) situation;
- (4) FIG. 3 show views for comparing a vehicle having a TCS function and a vehicle without having a TCS function; and
- (5) FIG. 4 is a flowchart illustrating a control process when the electronic control unit according to one embodiment of the present disclosure performs TCS control function.

DETAILED DESCRIPTION OF THE INVENTION

(6) Hereinafter, some exemplary embodiments of the present disclosure will be described in detail with reference to the accompanying drawings. In the following description, like reference numerals preferably designate like elements, although the elements are shown in different drawings. Further, in the following description of some embodiments, a detailed description of known functions and configurations incorporated therein will be omitted for the purpose of clarity and for brevity.

(7) Additionally, various terms such as first, second, A, B, (a), (b), etc., are used solely to differentiate one component from the other but not to imply or suggest the substances, order, or sequence of the components. Throughout this specification, when a part 'includes' or 'comprises' a component, the part is meant to further include other components, not to exclude thereof unless specifically stated to the contrary. The terms such as 'unit', 'module', and the like refer to one or more units for processing at least one function or operation, which may be implemented by hardware, software, or a combination thereof.

(8) FIG. 1 is a hydraulic circuit diagram illustrating a braking device according to one embodiment of the present disclosure.

(9) Referring to FIG. 1, a braking device **100** for a vehicle according to the embodiment of the present disclosure includes at least a back-up master cylinder **110**, a main master cylinder **120**, wheel brakes **131**, **132**, **133** and **134**, an electronic control unit (ECU) **140**, and a motor **152**.

(10) The back-up master cylinder **110** includes all or some of a back-up body **111**, a first back-up

piston **112**, a second back-up piston **113**, a first back-up chamber **118**, and a second back-up chamber **119**.

(11) The back-up body **111** is formed in a structure of which an inner portion is empty. The first back-up piston **112** and the second back-up piston **113** are disposed in an inner space of the back-up body **111** to be linearly movable in a lateral direction. The inner space of the back-up body **111** is divided into the first back-up chamber **118** corresponding to a space between the first back-up piston **112** and the second back-up piston **113** and the second back-up chamber **119** positioned at a left side of the first back-up chamber **118**.

(12) The main master cylinder **120** is driven by the motor **152** controlled by the ECU **140**, generates hydraulic pressure in main chambers **125** and **126**, and provides the hydraulic pressure to the wheel brakes **131**, **132**, **133** and **134**. In this case, the ECU **140** may be an ECU which is a typical control unit of a vehicle. When a driver depresses a brake pedal **101**, a stroke sensor **102** detects a stroke of the brake pedal **101** and transmits the stroke to the ECU **140**, and the ECU **140** controls the hydraulic pressure generated in the main master cylinder **120** by controlling the motor **152** on the basis of the stroke, which is detected by the stroke sensor **102**, of the brake pedal **101**.

(13) The main master cylinder **120** includes a main body **121**, a main piston **122**, and a rod **123**.

(14) The main body **121** is formed in a structure of which an inner portion is empty. The main piston **122** is disposed in an inner space of the main body **121** to be linearly movable in the lateral direction. The inner space of the main body **121** is divided into two spaces, which include a first main chamber **125** that is a space disposed at a right side with respect to the main piston **122** and a second main chamber **126** that is a space disposed at a left side with respect to the main piston **122**, by the main piston **122**.

(15) In the present specification, the terms “left side” and “right side” are only for indicating directions in which components are illustrated in the drawings, and the contents of the present disclosure are not interpreted as being limited to the arrangement directions and positions thereof.

(16) When the main piston **122** moves forward in a right direction, the first main chamber **125** becomes narrow, and the second main chamber **126** becomes wider. Conversely, when the main piston **122** moves rearward in a left direction, the first main chamber **125** becomes wider, and the second main chamber **126** becomes narrow.

(17) The wheel brakes **131**, **132**, **133** and **134** include a first wheel brake **131** which brakes a front left wheel of the vehicle, a second wheel brake **132** which brakes a front right wheel of the vehicle, a third wheel brake **133** which brakes a rear right wheel vehicle of the vehicle, and a fourth wheel brake **134** which brakes a rear left wheel of the vehicle. In the present disclosure, the front, rear, left, or right wheel brake may be changed within a range of a technical level of those skilled in the art.

(18) Coupling relationships between the back-up master cylinder **110**, the main master cylinder **120**, and the wheel brakes **131**, **132**, **133** and **134** will be described.

(19) The first wheel brake **131** and the second wheel brake **132** are connected through a first brake line **161**. That is, one end of the first brake line **161** is connected to the first wheel brake **131**, and the other end thereof is connected to the second wheel brake **132**.

(20) A first inlet valve **181** and a second inlet valve **182** which open or close the first brake line **161** are installed on the first brake line **161**. The first inlet valve **181** is disposed adjacent to the first wheel brake **131**, and the second inlet valve **182** is disposed adjacent to the second wheel brake **132**.

(21) One end of a first collection line **162** is connected to the first brake line **161** corresponding to a line between the first wheel brake **131** and the first inlet valve **181**. In addition, the other end of the first collection line **162** is connected to the first brake line **161** corresponding to a line between the second wheel brake **132** and the second inlet valve **182**.

(22) A first outlet valve **185** and a second outlet valve **186** which open or close the first collection line **162** are installed on the first collection line **162**. The first outlet valve **185** is disposed adjacent

to one end of the first collection line **162**, and the second outlet valve **186** is disposed adjacent to the other end of the first collection line **162**.

(23) The third wheel brake **133** and the fourth wheel brake **134** are connected through a second brake line **163**. That is, one end of the second brake line **163** is connected to the third wheel brake **133**, and the other end thereof is connected to the fourth wheel brake **134**.

(24) A third inlet valve **183** and a fourth inlet valve **184** which open or close the second brake line **163** are installed on the second brake line **163**. The third inlet valve **183** is disposed adjacent to the third wheel brake **133**, and the fourth inlet valve **184** is adjacent to the fourth wheel brake **134**.

(25) A check valve (not shown), which prevents a reverse flow of a brake fluid, is installed each of the first inlet valve **181**, the second inlet valve **182**, the third inlet valve **183**, and the fourth inlet valve **184**.

(26) Meanwhile, a first pressure sensor **103** is installed on the first brake line **161** corresponding to a line between the first inlet valve **181** and the second inlet valve **182**, and a second pressure sensor **104** is installed on the second brake line **163** corresponding to a line between the third inlet valve **183** and the fourth inlet valve **184**.

(27) One end of a second collection line **164** is connected to the second brake line **163** corresponding to a line between the third wheel brake **133** and the third inlet valve **183**. In addition, the other end of the second collection line **164** is connected to the second brake line **163** corresponding to a line between the fourth wheel brake **134** and the fourth inlet valve **184**. A third outlet valve **187** and a fourth outlet valve **188** which open or close the second collection line **164** are installed on the second collection line **164**. The third outlet valve **187** is disposed adjacent to one end of the second collection line **164**, and the fourth outlet valve **188** is disposed adjacent to the other end of the second collection line **164**.

(28) One end of a first main line **165** is connected to the first main chamber **125**. That is, one end of the first main line **165** is connected to the main body **121** so as to fluidly communicate with the first main chamber **125**. The other end of the first main line **165** is connected to the first brake line **161** corresponding to the line between the first inlet valve **181** and the second inlet valve **182**.

(29) A first traction control valve **191** which opens or closes the first main line **165** is installed on the first main line **165**. The first traction control valve **191** may be a solenoid valve controlled by the ECU **140** to open or close the first main line **165** and may be installed on a line through which the hydraulic pressure of the first main chamber **125** is supplied to each of the wheel brakes **131**, **132**, **133** and **134**.

(30) One end of a second main line **166** is connected to the second main chamber **126**. That is, one end of the second main line **166** is connected to the main body **121** so as to fluidly communicate with the second main chamber **126**. In addition, the other end of the second main line **166** is connected to the second brake line **163** corresponding to the line between the third inlet valve **183** and the fourth inlet valve **184**.

(31) A second traction control valve **192** which opens or closes the second main line **166** is installed on the second main line **166**. The second traction control valve **192** is a solenoid valve controlled by the ECU **140** to open or close the second main line **166** and is installed on a line through which the hydraulic pressure of the second main chamber **126** is supplied to each of the wheel brakes **131**, **132**, **133** and **134**.

(32) One end of a combined line is connected to the first main line **165**. In addition, the other end of the combined line is connected to the second main line **166**. A mixing valve **193** which opens or closes the combined line is installed on the combined line.

(33) One end of a first back-up line **171** is connected to the first back-up chamber **118**, and the other end of the first back-up line **171** is connected to the second back-up chamber **119**. That is, one end of the first back-up line **171** is connected to the back-up body **111** so as to fluidly communicate with the first back-up chamber **118**, and the other end thereof is connected to the back-up body **111** so as to fluidly communicate with the second back-up chamber **119**. A reservoir **190** in which a

brake fluid is stored is installed on the first back-up line **171**.

(34) One end of a third collection line **168** is connected to the reservoir **190**. In addition, the other end of the third collection line **168** branches into two lines, one line is connected to the first collection line **162** corresponding to a line between the first outlet valve **185** and the second outlet valve **186**, and the other one line is connected to the second collection line **164** corresponding to a line between the third outlet valve **187** and the fourth outlet valve **188**.

(35) One end of a second back-up line **172** is connected to the second back-up chamber **119**. That is, one end of the second back-up line **172** is connected to the back-up body **111** so as to fluidly communicate with the second back-up chamber **119**. The other end of the second back-up line **172** is connected to the first back-up line **171** corresponding to a line between the reservoir **190** and the back-up body **111**.

(36) A first back-up valve **194** which opens or closes the second back-up line **172** is installed on the second back-up line **172**.

(37) One end of a fifth back-up line **175** is connected to the first back-up chamber **118**. That is, one end of the fifth back-up line **175** is connected to the back-up body **111** so as to fluidly communicate with the first back-up chamber **118**. In addition, the other end of the fifth back-up line **175** is connected to the main body **121**. A third back-up valve **196** which opens or closes the fifth back-up line **175** is installed on the fifth back-up line **175**. In addition, a pressure sensor (not shown) which measures a brake fluid pressure in the fifth back-up line **175** is installed on the fifth back-up line **175**. The pressure sensor is installed on the fifth back-up line **175** corresponding to a line between the back-up body **111** and the third back-up valve **196**.

(38) One end of a sixth back-up line **176** is connected to the second back-up chamber **119**. That is, one end of the sixth back-up line **176** is connected to the back-up body **111** so as to fluidly communicate with the second back-up chamber **119**. In addition, the other end of the sixth back-up line **176** is connected to the second main line **166** corresponding to a line between one end of the second main line **166** and the other end of a third back-up line **173**. A fourth back-up valve **197** which opens or closes the sixth back-up line **176** is installed on the sixth back-up line **176**.

(39) The first inlet valve **181** to the fourth inlet valve **184**, the first outlet valve **185** to the fourth outlet valve **188**, the first traction control valve **191** and the second traction control valve **192**, the mixing valve **193**, and the first back-up valve **194** to the fourth back-up valve **197** are formed as solenoid valves controlled by the ECU **140**.

(40) Each of the first inlet valve **181**, the second inlet valve **182**, the third inlet valve **183**, and the fourth inlet valve **184** is formed as a normal open type which is normally open when a control signal is not input from the ECU **140**.

(41) In addition, each of the first outlet valve **185**, the second outlet valve **186**, the third outlet valve **187**, and the fourth outlet valve **188** is formed as a normal closed type which is normally closed when a control signal is not input from the ECU **140**.

(42) Each of the first traction control valve **191** and the second traction control valve **192** is formed as a normal open type. In addition, the mixing valve **193** is formed as a normal closed type.

(43) The first back-up valve **194** is formed as a normal closed type. In addition, each of the second back-up valve **195**, the third back-up valve **196**, and the fourth back-up valve **197** is formed as a normal open type.

(44) When a brake of the vehicle is controlled by the ECU **140**, the ECU **140** closes all of the second back-up valve **195**, the third back-up valve **196**, and the fourth back-up valve **197**. Then, since all of the first, second, third, fourth back-up valves **194**, **195**, **196**, and **197** are in closed states, a line between the back-up master cylinder **110** and the main master cylinder **120** is blocked. Accordingly, in this case, the wheel brakes **131**, **132**, **133** and **134** generate braking forces using only hydraulic pressure supplied by the main master cylinder **120**.

(45) However, when power is not supplied to the ECU **140**, the second back-up valve **195**, the third back-up valve **196**, and the fourth back-up valve **197** maintain open states because of being formed

as normal open types.

(46) In addition, in the case in which power is not supplied to the ECU **140**, when the driver depresses the brake pedal **101**, the hydraulic pressure generated in the second back-up chamber **119** by receiving a brake fluid supplied from the reservoir **190** is supplied to the second main chamber **126** through the sixth back-up line **176**.

(47) The fourth back-up valve **197** is formed on the sixth back-up line **176** which connects the back-up master cylinder **110** and the main master cylinder **120**. When the ECU **140** breaks down, the fourth back-up valve **197** is configured to generate a braking force using the back-up master cylinder **110**, and for example, the fourth back-up valve **197** is formed as a normal open type in which an open state is maintained even when a current is not supplied.

(48) FIG. **2** is a hydraulic circuit diagram illustrating a flow of a brake fluid in order for the electronic control unit according to one embodiment of the present disclosure to increase or decrease a pressure in the hydraulic circuit in a traction control system (TCS) situation.

(49) Referring to FIG. **2**, a thick solid line shows a flow of a brake fluid.

(50) A traction control system (TCS) function is a function of preventing idling of a tire to prevent the tire from slipping when a vehicle travels. When the vehicle travels on a snowy road, a rainy road, or the like in a state in which a road surface is slippery, a difference in number of rotations occurs between a left wheel and a right wheel. For example, a slippery road surface causes a tire to spin, and accordingly, the difference in number of rotations occurs between the left wheel and the right wheel. The TCS function is to prevent the difference in number of rotations from occurring between the left wheel and the right wheel by preventing idling of the tire.

(51) When the main piston **122** moves forward, the electronic control unit **140** closes the second traction control valve **192**, the third back-up valve **196**, and the fourth back-up valve **197** and opens the first traction control valve **191**, the mixing valve **193**, and the first back-up valve **194**.

(52) Since the first traction control valve **191** and the second back-up valve **195** formed as normally open types maintain open states even when a current does not flow therein, the electronic control unit **140** may decrease current consumption by minimizing the number of solenoid valves to which a current is supplied in a multi-wheel control mode.

(53) Meanwhile, a duty ratio, which is greater than or equal to a predetermined level, is applied to the electronic control unit **140** so that the second traction control valve **192** is not opened.

(54) A process in which the electronic control unit **140** according to one embodiment of the present disclosure controls a low-pressure wheel brake and a high-pressure wheel brake will be described in detail with reference to FIG. **4**.

(55) FIG. **3** shows views for comparing a vehicle having a TCS function and a vehicle without having a TCS function;

(56) FIG. **3A** is a view illustrating an understeering situation in which the front wheels of the vehicle slip, FIG. **3B** is a view illustrating an oversteering situation in which the rear wheels of the vehicle slip, and FIG. **3C** is a view for comparing a vehicle having TCS function and a vehicle without having a TCS function.

(57) Referring to FIG. **3A**, a cornering force generated at the rear wheel increases when the vehicle turns left with a constant radius at a constant speed. In this case, since a moment of the right front wheel or the rear wheel of the vehicle increases when compared to that of the left front wheel, even when the driver maintains a constant steering angle, a turning radius of the vehicle increases.

(58) Meanwhile, in FIG. **3B**, a cornering force generated at the front wheel increases when the vehicle turns left with a constant radius and at a constant speed. In this case, since a moment of the left front wheel or rear wheel of the vehicle increases when compared to that of the right front wheel, even when the driver maintains a constant steering angle, a turning radius of the vehicle decreases.

(59) That is, in the situations of FIGS. **3A** and **3B**, when the TCS function of the vehicle does not work, the vehicle may slip and overturn.

(60) Conversely, referring to FIG. 3C, in a vehicle in which a TCS is installed, since each of the wheels independently generates a braking force when the vehicle turns, the vehicle is not idling. Accordingly, when the vehicle in which the TCS is installed turns, the vehicle may turn a corner without slipping. In addition, the vehicle in which the TCS is installed may travel without slipping when traveling on a slippery road surface, for example, an icy surface.

(61) FIG. 4 is a flowchart illustrating a control process when the electronic control unit according to one embodiment of the present disclosure performs a TCS control function;

(62) Referring to FIG. 4, the electronic control unit **140** determines whether to start TCS control (**S410**). For example, the determination of the whether to start the TCS control function may be determined on the basis of yaw rate information detected by a yaw rate sensor installed in the vehicle. In addition, the electronic control unit **140** may determine to start the TCS control function when the wheel is idling, the driver suddenly accelerates the vehicle, or the vehicle slips.

(63) When it is determined that the TCS control function do not start, the electronic control unit **140** performs initial position control, that is, piston initialization (**S415**).

(64) On the other hand, when it is determined that the TCS control function starts, the electronic control unit **140** calculates a pressure, that is, a required pressure, needed to generate a braking force at a wheel brake so that the vehicle does not slip (**S420**). For example, the electronic control unit **140** may calculate what level of a braking force should be generated by which wheel brake and calculate a required pressure needed for the wheel brake on the basis of the yaw rate information detected by the yaw rate sensor.

(65) When the required pressure is completely calculated, the electronic control unit **140** determines whether a control mode is a single wheel control mode when performing the TCS control (**S430**).

(66) The control mode according to one embodiment of the present disclosure includes the single wheel control mode and a multi-wheel control mode. The single wheel control mode is a control mode in which, when the electronic control unit **140** performs the TCS control function, hydraulic pressure is supplied to only one wheel brake, and the multi-wheel control mode is a control mode in which, when the electronic control unit **140** performs the TCS control function, hydraulic pressures are supplied to at least two wheel brakes.

(67) When it is determined that the control mode is the single wheel control mode, the electronic control unit **140** performs pressure control and valve control (**S435**). The pressure control corresponds to a control method in which the electronic control unit **140** supplies a current to the motor **152** so that the motor **152** rotates to move the main piston **122** in a forward direction so as to generate hydraulic pressure. Meanwhile, the valve control corresponds to a control method of opening or closing the solenoid valve to transmit the hydraulic pressure, which is generated through the pressure control, to the wheel brake. In addition, the pressure control includes forward pressure control and rearward pressure control. The forward pressure control corresponds to a control method in which the main piston **122** moves forward (in a rightward direction in FIG. 1) to generate hydraulic pressure, and the rearward pressure control corresponds to a control method in which the main piston **122** moves rearward (in a leftward direction in FIG. 1) to generate hydraulic pressure.

(68) The electronic control unit **140** according to one embodiment of the present disclosure may change a movement direction of the main piston **122** when the main piston **122** moves forward or rearward and reaches a maximum displacement or minimum displacement at which the main piston **122** may move. That is, the electronic control unit **140** may determine whether a direction change condition is satisfied on the basis of a displacement of the main piston **122**, and when the direction change condition is satisfied, the electronic control unit **140** may change the movement direction of the main piston **122**. The electronic control unit **140** may apply a current to the motor **152** to change the movement direction of the main piston **122**.

(69) Operation **S435** will be described in more detail. In order to prevent the vehicle from slipping,

the electronic control unit **140** opens the inlet valve connected to the wheel brake in which the braking force should be generated. Meanwhile, the inlet valve connected to the wheel brake in which a braking force is not generated is closed. For example, in order to generate a braking force in the first wheel brake **131**, the first inlet valve **181** is opened, and the second inlet valve **182**, the third inlet valve **183**, and the fourth inlet valve **184** are closed.

(70) On the other hand, when it is determined that the control mode is the multi-wheel control mode, the electronic control unit **140** determines the high-pressure wheel brake and the low-pressure wheel brake (**S440**).

(71) In the multi-wheel control mode, since at least two wheel brakes generate braking forces, a wheel brake, which generates a relatively large braking force is referred to as the high-pressure wheel brake, and a wheel brake generates a relatively small braking force is referred to as the low-pressure wheel brake.

(72) For example, when the first wheel brake **131** and the fourth wheel brake **134** installed at a left side of the vehicle generate braking forces, a wheel brake generating a relatively large braking force is the high-pressure wheel brake.

(73) When the high-pressure wheel brake and the low-pressure wheel brake are determined, the electronic control unit **140** performs the pressure control and the valve control (**S445**).

(74) Operation **S445** will be described in more detail. In order to prevent the vehicle from slipping, the electronic control unit **140** opens the inlet valve connected to the high-pressure wheel brake which should generate the braking force among the wheel brakes. Accordingly, the hydraulic pressure generated through the pressure control is supplied to the high-pressure wheel brake.

(75) In addition, the electronic control unit **140** controls the inlet valve and the outlet valve connected to the low-pressure wheel brake. For example, the hydraulic pressure is supplied by opening the inlet valve, and a pressure is decreased using the outlet valve. That is, the pressure supplied to the low-pressure wheel brake is maintained as a low pressure by partially decreasing the hydraulic pressure, which is generated through the pressure control, using the outlet valve.

(76) Meanwhile, the inlet valve connected to the wheel brake which does not generate a braking force is closed.

(77) In addition, in operation **S445**, a supplemental current is further supplied to the motor **152** in order to prevent a sudden drop in the hydraulic circuit. In this case, the drop means that the pressure generated in the hydraulic circuit is released by momentarily switching the solenoid valve, which maintains a closed state, to an open state. That is, in a drop state, even when the motor **152** rotates, hydraulic pressure is not supplied to the wheel brake.

(78) Accordingly, the electronic control unit **140** according to one embodiment of the present disclosure may further supply the assist current to the motor **152** so that the drop does not occur in operation **S445**.

(79) After operations **S415**, **S435**, and **S445** are performed, the present algorithm is finished.

(80) Although exemplary embodiments of the present disclosure have been described for illustrative purposes, those skilled in the art will appreciate that various modifications, additions, and substitutions are possible, without departing from the idea and scope of the claimed invention. Therefore, exemplary embodiments of the present disclosure have been described for the sake of brevity and clarity. The scope of the technical idea of the present embodiments is not limited by the illustrations. Accordingly, one of ordinary skill would understand the scope of the claimed invention is not to be limited by the above explicitly described embodiments but by the claims and equivalents thereof

Claims

1. A braking device for a vehicle, the braking device comprising a reservoir, a back-up master cylinder, a main master cylinder, a plurality of valves, a motor, and a plurality of wheel brakes, the

main master cylinder including a main piston, and the motor configured to move the main piston, the braking device configured to: determine whether a traction control system (TCS) function needs to be performed, the TCS function including preventing a wheel of the vehicle from idling; in response to determining that the TCS function needs to be performed, calculate a plurality of required pressures for the plurality of wheel brakes, respectively, to perform the TCS function; based on the calculated plurality of required pressures for the plurality of wheel brakes, determine how many of the plurality of wheel brakes needs to be supplied with a hydraulic pressure to perform the TCS function; in response to determining that only one of the plurality of wheel brakes needs to be supplied with the hydraulic pressure to perform the TCS function, supply, to the only one wheel brake, a first hydraulic pressure that causes the only one wheel brake to provide a first required pressure to perform the TCS function; and in response to determining that two or more of the plurality of wheel brakes need to be supplied with the hydraulic pressures to perform the TCS function, (1) determine, from the plurality of wheel brakes, a high-pressure wheel brake for generating a second required braking force to perform the TCS function and a low-pressure wheel brake for generating a third required braking force to perform the TCS function, the third required braking force being smaller than the second required braking force, and (2) supply, to the high-pressure and low-pressure wheel brakes, second and third hydraulic pressures, respectively, that cause the high-pressure and low-pressure brakes to respectively provide the second and third required pressures to perform the TCS function, wherein the braking device is further configured to supply a supplemental current to the motor to prevent a drop in the hydraulic pressure in the high-pressure wheel brake when the second and third hydraulic pressures are respectively supplied to the high-pressure and low-pressure wheel brakes.

2. The braking device of claim 1, further comprising a yaw rate sensor configured to detect a yaw rate information of the vehicle, wherein the braking device is further configured to determine whether the TCS function needs to be performed based on the yaw rate information.

3. The braking device of claim 1, further configured to: determine, based on a displacement of the main piston, whether a direction change condition is satisfied; and control a current applied to the motor to change a movement direction of the main piston in response to determining that the direction change condition is satisfied.

4. The braking device of claim 3, wherein the direction change condition is satisfied when the main piston moves forward to reach a maximum or minimum displacement.

5. The braking device of claim 1, wherein, to supply the first hydraulic pressure to the only one wheel brake, the braking device is further configured to open an inlet valve connected to the only one wheel brake and close inlet valves connected respectively to other wheel brakes.

6. The braking device of claim 1, wherein, to supply the second and third hydraulic pressures respectively to the high-pressure and low-pressure wheel brakes, the braking device is further configured to: open an inlet valve connected to the high-pressure wheel brake to supply the second hydraulic pressure to the high-pressure wheel brake; control inlet and outlet valves connected to the low-pressure wheel brake in order to supply the third hydraulic pressure, less than the second hydraulic pressure, to the low-pressure wheel brake; and close an inlet valve connected to other wheel brakes.

7. The braking device of claim 1, further configured to start performing the TCS function when at least one of a plurality of wheels is idling.

8. The braking device of claim 1, further configured to start performing the TCS function when the vehicle accelerates suddenly or slips.
