

LOCOMOTIVE BRAKE CONTROL SYSTEM AND CONTROL METHOD

The present application claims the priority benefit of Chinese application No. 2023109090356, filed on July 24, 2023, entitled "locomotive brake control system and control method", the entirety of which is hereby incorporated by reference.

TECHNICAL FIELD

The present application belongs to the field of locomotive brake control, and specifically relates to a locomotive brake control system and control method.

BACKGROUND

Locomotive brake control system is one of the most important core systems of a locomotive, one key function of the system is to control the pressure of a brake cylinder, and the locomotive brake control system achieves braking and relieving functions of the locomotive by controlling the pressure value of the brake cylinder. A conventional method for pressure control of the brake cylinder is to control a pre-control pressure by a high-frequency magnet valve, and then output a brake cylinder pressure consistent with the pre-control pressure through a relay valve. In order to avoid impacts of brake cylinder control failure on the operation of the locomotive, a pre-control pressure control part that is prone to failure is usually backed up.

Existing locomotive brake control systems mainly comprise a CCBII system developed by Knorr-Bremse Company and an Eurotrol system developed by Faiveley Company. Both of the brake control systems adopt mechanical air distribution valves to perform redundancy control of the pre-control pressure part of the brake cylinder. On one hand, the redundancy control method greatly reduces the pressure control precision of the brake cylinder when mechanical valves perform redundancy control, and on the other hand, pressure control of the brake cylinder cannot be achieved when the relay valve of the brake cylinder fails.

CN111634304A discloses a locomotive brake control system and control method. The system includes an equalizing pipe control system and a brake cylinder control system, wherein the brake cylinder control system is able to compare a pre-control pressure of the brake cylinder with a pre-control pressure of the equalizing pipe control system, and output a higher pressure as an equalizing pipe pressure; the brake cylinder control system is able to compare the pre-control

pressure of the brake cylinder with the equalizing pipe pressure, and output a higher pressure as a brake cylinder pressure to achieve braking; thus redundancy of the two control systems can be achieved.

5 SUMMARY

For some problems existing in the prior art, the present application provides a locomotive brake control system and control method, by which multi-redundancy can be achieved, and the reliability of the system can be improved.

A first aspect of the present application provides a locomotive brake control system,
10 including an equalizing pipe control module, a brake cylinder control module and a total air; wherein,

the equalizing pipe control module includes a first air-charging magnet valve and a first air-discharging magnet valve both connected with the total air and capable of controlling and outputting a pressure of the inputted total air as a desired first pre-control pressure P1 through an
15 air charging action and an air discharging action.

The equalizing pipe control module further includes a first relay valve and a first switching valve; wherein, the first pre-control pressure P1 reaches a control port of the first relay valve; an inlet of the first relay valve is connected with the total air, and an amplified first pre-control pressure is outputted as an equalizing pipe pressure PA through an outlet of the first relay valve.

20 A first branch PA1 of the equalizing pipe pressure PA is connected to a first inlet of a first shuttle valve of the brake cylinder control module by a pipeline; a second branch PA2 of the equalizing pipe pressure PA is connected to an inlet of the first switching valve by a pipeline; and the second branch PA2 is able to be outputted through an outlet of the first switching valve to reach a first inlet of a third shuttle valve of the brake cylinder control module.

25 The brake cylinder control module includes a second air-charging magnet valve and a second air-discharging magnet valve both connected with the total air and capable of controlling and outputting a pressure of the inputted total air as a desired second pre-control pressure P2 through an air charging action and an air discharging action.

The brake cylinder control module further includes a second switching valve, a mechanical
30 three-way valve and the first shuttle valve; wherein, the second pre-control pressure P2 is connected to a first inlet of the second switching valve.

The mechanical three-way valve is a mechanical valve capable of outputting a third pre-control pressure P3. A first inlet of the mechanical three-way valve is connected with a train pipe to be supplied with an air source; and an outlet of the mechanical three-way valve is connected to a second inlet of the second switching valve to output the third pre-control pressure P3.

The second switching valve is able to switch between the first inlet and the second inlet to select the second pre-control pressure P2 or the third pre-control pressure P3, and an outlet of the second switching valve communicates to a second inlet of the first shuttle valve.

An outlet of the first shuttle valve is connected to a control port of a second relay valve, so that a higher pressure in the first inlet and the second inlet of the first shuttle valve is selected as a fourth pre-control pressure P4 to be outputted to the control port of the second relay valve.

An inlet of the second relay valve is connected with the total air, and an outlet thereof is connected to a second inlet of the third shuttle valve, so that an amplified fourth pre-control pressure is outputted as a first brake cylinder pressure PB1 to the second inlet of the third shuttle valve.

An outlet of the third shuttle valve is connected to a brake cylinder, so that a higher pressure in the first inlet and the second inlet of the third shuttle valve is selected as a second brake cylinder pressure PB2 to be outputted to the brake cylinder for braking.

In some embodiments, the brake cylinder control module further includes a second shuttle valve, a relief valve and an emergency booster valve; wherein,

the outlet of the first shuttle valve is connected to a first inlet of the second shuttle valve, so that the higher pressure in the first inlet and the second inlet of the first shuttle valve is selected as the fourth pre-control pressure P4 to be outputted to the first inlet of the second shuttle valve (here, P4 is no longer directly outputted to the control port of the second relay valve);

an inlet of the relief valve is connected with the total air, and an outlet of the relief valve is connected to an inlet of the emergency booster valve; a fifth pre-control pressure P5 is outputted to a second inlet of the second shuttle valve through an outlet of the emergency booster valve; a control port of the emergency booster valve is connected with the train pipe to be supplied with a control air source to open or close the emergency booster valve, with switching on or switching off the output of the fifth pre-control pressure P5; and

an outlet of the second shuttle valve is connected to the control port of the second relay

valve, so that a higher pressure in the first inlet and the second inlet of the second shuttle valve is selected as a sixth pre-control pressure P6 (replacing the fourth pre-control pressure P4 when there is no the second shuttle valve) to be outputted to the control port of the second relay valve.

In some embodiments, the mechanical three-way valve selects an adjustable three-way valve;
5 and a second inlet of the mechanical three-way valve is connected with a working reservoir, and when a pressure of the train pipe changes, the train pipe and the working reservoir are dynamically balanced.

In some embodiments, a first pre-control reservoir is provided on a pipeline where the first pre-control pressure P1 is located, capable of storing compressed air to supply an air source as
10 the first pre-control pressure P1.

In some embodiments, a second pre-control reservoir is provided on a pipeline where the sixth pre-control pressure P6 is located, for storing compressed air to supply an air source as the sixth pre-control pressure P6.

In some embodiments, an action reservoir is provided on a pipeline where the third pre-control pressure P3 is located, for storing compressed air to supply an air source as the third
15 pre-control pressure P3.

In some embodiments, the second switching valve is a mechanical switching valve with a control port; when there is an air source at the control port of the second switching valve, the second pre-control pressure P2 is communicated with; and when there is no air source at the
20 control port of the second switching valve, the third pre-control pressure P3 is switched to be communicated with.

In some embodiments, in the brake cylinder control module, an electric control valve is provided for controlling the second switching valve to be switched between the second pre-control pressure P2 and the third pre-control pressure P3; wherein an inlet of the electric
25 control valve is connected with the total air, and an outlet thereof is connected to the control port of the second switching valve; and the electric control valve is configured to: when energized, communicate the total air with the control port of the second switching valve so that the second switching valve communicates with the second pre-control pressure P2; and when de-energized, cut off the total air with the control port of the second switching valve so that the second
30 switching valve communicates with the third pre-control pressure P3.

A second aspect of the present application provides a locomotive brake control method,

might adopting the locomotive brake control system in any embodiments previously mentioned, and the control method includes at least one of the following three states:

(1) Normal working state

5 In the equalizing pipe control module:

The pressure of the inputted total air is controlled and outputted as the desired first pre-control pressure P1 by the first air-charging magnet valve and the first air-discharging magnet valve through the air charging action and the air discharging action, and acts on the control port of the first relay valve; the total air is inputted through the inlet of the first relay valve, after flow amplification, the equalizing pipe pressure PA is outputted through the outlet of the first relay valve; and the first branch PA1 of the equalizing pipe pressure reaches the first inlet of the first shuttle valve of the brake cylinder control module.

The first switching valve is in a closed state, so that the second branch PA2 of the equalizing pipe pressure is not supplied to the first inlet of the third shuttle valve.

15 In the brake cylinder control module:

The pressure of the inputted total air is controlled and outputted as the desired second pre-control pressure P2 by the second air-charging magnet valve and the second air-discharging magnet valve through the air charging action and the air discharging action.

The electric control valve is energized, and the total air reaches the control port of the second switching valve, so that the second pre-control pressure P2 enters the second switching valve and reaches the second inlet of the first shuttle valve.

The first shuttle valve selects a higher pressure between the first branch PA1 of the equalizing pipe pressure and the second pre-control pressure P2, and outputs as the fourth pre-control pressure P4 acting on the control port of the second relay valve; and the total air is inputted through the inlet of the second relay valve, and after flow amplification, the first brake cylinder pressure PB1 is outputted to the second inlet of the third shuttle valve through the outlet of the second relay valve.

The third shuttle valve outputs the first brake cylinder pressure PB1 as the second brake cylinder pressure PB2, reaching the brake cylinder to achieve braking.

30 **(2) The brake cylinder control module in a fault state**

In the equalizing pipe control module:

The pressure of the inputted total air is controlled and outputted as the desired first pre-control pressure P1 by the first air-charging magnet valve and the first air-discharging magnet valve through the air charging action and the air discharging action, and acts on the control port of the first relay valve; the total air is inputted through the inlet of the first relay valve, after flow amplification, the equalizing pipe pressure PA is outputted through the outlet of the first relay valve; and the first branch PA1 of the equalizing pipe pressure reaches the first inlet of the first shuttle valve of the brake cylinder control module.

The first switching valve is in a closed state, so that the second branch PA2 of the equalizing pipe pressure cannot be supplied to the first inlet of the third shuttle valve.

In the brake cylinder control module:

The second pre-control pressure P2 is unable to be normally outputted in the brake cylinder control module.

The electric control valve is de-energized, and no air source reaches the control port of the second switching valve, so that the second switching valve is switched to connect with the mechanical three-way valve; and the third pre-control pressure P3 is generated by the mechanical three-way valve according to the pressure change of the train pipe, and is outputted to the second inlet of the first shuttle valve.

The first shuttle valve selects the higher pressure between the first branch PA1 of the equalizing pipe pressure and the third pre-control pressure P3, and outputs as the fourth pre-control pressure P4 acting on the control port of the second relay valve; and the total air is inputted through the inlet of the second relay valve, and after flow amplification, the first brake cylinder pressure PB1 is outputted to the second inlet of the third shuttle valve through the outlet of the second relay valve.

The third shuttle valve outputs the first brake cylinder pressure PB1 as the second brake cylinder pressure PB2, reaching the brake cylinder to achieve braking.

(3) The second relay valve in a fault state

In the equalizing pipe control module:

The pressure of the inputted total air is controlled and outputted as the desired first pre-control pressure P1 by the first air-charging magnet valve and the first air-discharging magnet valve through the air charging action and the air discharging action, and acts on the

control port of the first relay valve; the total air is inputted through the inlet of the first relay valve, and after flow amplification, the equalizing pipe pressure PA is outputted through the outlet of the first relay valve.

Wherein, the first branch PA1 of the equalizing pipe pressure reaches the first inlet of the first shuttle valve of the brake cylinder control module; and the first switching valve is in an open state, so that the second branch PA2 of the equalizing pipe pressure is supplied to the first inlet of the third shuttle valve.

In the brake cylinder control module:

The second relay valve fails, so that the first brake cylinder pressure PB1 is unable to be effectively outputted.

The third shuttle valve outputs the second branch PA2 of the equalizing pipe pressure as the second brake cylinder pressure PB2, reaching the brake cylinder to achieve braking.

In some embodiments, when the brake cylinder control module has the second shuttle valve, the relief valve and the emergency booster valve:

For (1) the normal working state:

The first shuttle valve selects the higher pressure between the first branch PA1 of the equalizing pipe pressure and the second pre-control pressure P2, and outputs as the fourth pre-control pressure P4 to the first inlet of the second shuttle valve.

When a pressure of the train pipe drops to a threshold, the emergency booster valve is opened, and the fifth pre-control pressure P5 is outputted to the second inlet of the second shuttle valve. The second shuttle valve selects the higher pressure between the fourth pre-control pressure P4 and the fifth pre-control pressure P5, and outputs as the sixth pre-control pressure P6 (replacing the fourth pre-control pressure P4 when there is no the second shuttle valve) acting on the control port of the second relay valve; and the total air is inputted through the inlet of the second relay valve, and after flow amplification, the first brake cylinder pressure PB1 is outputted to the second inlet of the third shuttle valve through the outlet of the second relay valve.

When the pressure of the train pipe is higher than the threshold, the emergency booster valve is in a closed state; at this moment, the second shuttle valve only acquires the fourth pre-control pressure P4, and outputs as the sixth pre-control pressure P6 acting on the control port of the second relay valve; and the total air is inputted through the inlet of the second relay valve, and

after flow amplification, the first brake cylinder pressure PB1 is outputted to the second inlet of the third shuttle valve through the outlet of the second relay valve.

For (2) the brake cylinder control module in the fault state:

5 The first shuttle valve selects the higher pressure between the first branch PA1 of the equalizing pipe pressure and the third pre-control pressure P3, and outputs as the fourth pre-control pressure P4 to the first inlet of the second shuttle valve.

When the pressure of the train pipe drops to the threshold, the emergency booster valve is opened, and the fifth pre-control pressure P5 is outputted to the second inlet of the second shuttle valve. The second shuttle valve selects a higher pressure between the fourth pre-control pressure P4 and the fifth pre-control pressure P5, and outputs as the sixth pre-control pressure P6 (replacing the fourth pre-control pressure P4 when there is no the second shuttle valve) acting on the control port of the second relay valve; and the total air is inputted through the inlet of the second relay valve, and after flow amplification, the first brake cylinder pressure PB1 is outputted to the second inlet of the third shuttle valve through the outlet of the second relay valve.

When the pressure of the train pipe is higher than the threshold, the emergency booster valve is in the closed state; at this moment, the second shuttle valve only acquires the fourth pre-control pressure P4, and outputs as the sixth pre-control pressure P6 acting on the control port of the second relay valve; and the total air is inputted through the inlet of the second relay valve, and after flow amplification, the first brake cylinder pressure PB1 is outputted to the second inlet of the third shuttle valve through the outlet of the second relay valve.

Compared with the prior art, the present application has the beneficial effects that:

According to the locomotive brake control system provided in at least one embodiment of the present application, when the air-charging magnet valves and the air-discharging magnet valves or the second relay valve for controlling the brake cylinder fails, redundancy control on the pressure of the brake cylinder can be achieved by multi-redundancy with the mechanical three-way valve, the equalizing pipe pressure and the emergency booster valve, etc.

BRIEF DESCRIPTION OF DRAWINGS

30 Fig. 1 is an operation schematic diagram of a control system in a normal working state according to one embodiment;

Fig. 2 is an operation schematic diagram of a brake cylinder control module in a fault state according to one embodiment;

Fig. 3 is an operation schematic diagram of a second relay valve in a fault state according to one embodiment;

5 Wherein, 1 equalizing pipe control module, 101 first air-charging magnet valve, 102 first air-discharging magnet valve, 103 first relay valve, 104 first switching valve, 105 first pre-control reservoir; 2 brake cylinder control module, 201 second air-charging magnet valve, 202 second air-discharging magnet valve, 203 second switching valve, 204 mechanical three-way valve, 205 first shuttle valve, 206 working reservoir, 207, action reservoir, 208 electric
10 control valve, 209 second shuttle valve, 210 relief valve, 211 emergency booster valve, 212 second relay valve, 213 second pre-control reservoir, 214 third shuttle valve, 215 brake cylinder; 3 total air; and 4 train pipe.

DETAILED DESCRIPTION OF THE EMBODIMENTS

15 The technical solutions of the present application will be described in detail below in combination with specific embodiments. However, it should be understood that elements, structures and features in one embodiment may also be advantageously incorporated into other embodiments without further description.

 In the description of the present application, it should be noted that terms such as "first" and
20 "second" are used for descriptive purposes only, and cannot be understood as indicating or implying the relative importance, or implicitly indicating the number of indicated technical features. Therefore, the features defined with "first" and "second" may explicitly or implicitly include one or more of these features.

 In the description of the present application, it should be noted that the terms "connect",
25 "connecting" and "connected" should be understood in a broad sense unless otherwise clearly specified and limited. For example, they might be fixed connection, detachable connection, or integrated connection; might be direct connection or indirect connection through an intermediate medium, and might be internal connection of two elements. For those of ordinary skill in the art, the specific meanings of the above-mentioned terms in the present application can be understood
30 under specific circumstances.

 In the present application, each of the relay valves has a flow amplification function and the

air source is provided through the inlet, and the pressure of the outputted gas from the outlet is consistent with the pressure supplied through the control port. Each of the shuttle valves in the present application has pressure comparison and selection function, and is able to automatically compare pressures at two inlets and select a higher pressure to be outputted through the outlet.

5 The relay valves and the shuttle valves all select mechanical valves, which can effectively deal with a de-energized state.

A first embodiment of the present application provides a locomotive brake control system, as shown in Figs. 1 to 3, comprising an equalizing pipe control module 1, a brake cylinder control module 2 and a total air 3, wherein:

10 (1) Equalizing pipe control module

The equalizing pipe control module 1 comprises a first air-charging magnet valve 101 and a first air-discharging magnet valve 102 which are connected to the total air 3 and which are capable of controlling and outputting a pressure of inputted total air 3 as a desired first pre-control pressure P1 through an air charging action and an air discharging action. The total air, 15 the first air-charging magnet valve 101 and the first air-discharging magnet valve 102 described herein are disposed in a conventional way in the art, which can be achieved by adopting a technical solution in the prior art, such as adopting the first total air, the first magnet valve and the second magnet valve in CN111634304A.

The equalizing pipe control module 1 further comprises a first relay valve 103 and a first 20 switching valve 104. The first pre-control pressure P1 is connected to a control port of the first relay valve 103, an inlet of the first relay valve 103 is connected with the total air 3, and an amplified first pre-control pressure is outputted as an equalizing pipe pressure PA through an outlet of the first relay valve. A first branch PA1 of the equalizing pipe pressure PA is connected to a first inlet of a first shuttle valve 205 of the brake cylinder control module 2 by a pipeline; a 25 second branch PA2 (as a standby) of the equalizing pipe pressure PA is connected to an inlet of the first switching valve 104 by a pipeline; and when the first switching valve 104 is opened, the second branch PA2 outputted through an outlet of the first switching valve 104 reaches a first inlet of a third shuttle valve 214 of the brake cylinder control module 2. The first switching valve 104 may be a magnet valve which is opened when energized and is closed when de-energized.

30 A first pre-control reservoir 105 is provided on a pipeline where the first pre-control pressure P1 locates, capable of storing compressed air to supply an air source as the first pre-control

pressure P1.

(2) Brake cylinder control module

The brake cylinder control module 2 comprises a second air-charging magnet valve 201 and a second air-discharging magnet valve 202 which are connected to the total air 3 and which are
5 capable of controlling and outputting a pressure of inputted total air 3 as a desired second pre-control pressure P2 through an air charging action and an air discharging action. The total air, the second air-charging magnet valve and the second air-discharging magnet valve described herein are also disposed in a conventional way in the art, which can be achieved by adopting a technical solution in the prior art, such as adopting the second total air, the third magnet valve
10 and the fourth magnet valve in CN111634304A.

The brake cylinder control module 2 further comprises a second switching valve 203, a mechanical three-way valve 204 and the first shuttle valve 205; wherein the second pre-control pressure P2 is connected to a first inlet of the second switching valve 203.

As shown in Fig. 2, the mechanical three-way valve 204 is a mechanical valve capable of
15 outputting a third pre-control pressure P3. In an embodiment, the mechanical three-way valve 204 may select an adjustable three-way valve. The working principle of the adjustable three-way valve is to change the position of the valve core to alter the direction and size of the fluid channel. The position of the valve core can be changed by a manual operating apparatus or by automatic control. If increased flow is desired, the valve core will move towards the inlet, allowing fluid to
20 pass more easily through the channel. On the contrary, if flow reduction is needed, the valve core will move towards the outlet, partially obstructing the pipeline to reduce flow.

A first inlet of the mechanical three-way valve 204 is connected with a train pipe 4 (also called a brake pipe) to be supplied with an air source; a second inlet of the mechanical three-way valve 204 is connected with a working reservoir 206; and when a pressure of the train pipe 4
25 changes, the train pipe 4 and the working reservoir 206 are dynamically balanced. An outlet of the mechanical three-way valve 204 is connected to a second inlet of the second switching valve 203, being able to output the third pre-control pressure P3.

An action reservoir 207 is provided on a pipeline where the third pre-control pressure P3 locates, for storing compressed air to supply an air source as the third pre-control pressure P3.

30 The mechanical three-way valve 204 uses the pressure of the train pipe 4 to supply air to the working reservoir 206. After the pressure of the train pipe 4 drops, a pressure of the working

reservoir 206 will be connected to the action reservoir 207, thereby controlling the action reservoir 207 to generate corresponding pressure. After the train is relieved, the mechanical three-way valve 204 controls the pressure of the train pipe output as the desired third pre-control pressure P3.

5 The first inlet of the second switching valve 203 communicates with the second pre-control pressure P2, the second inlet thereof communicates with the third pre-control pressure P3, and an outlet thereof communicates to a second inlet of the first shuttle valve 205; and the second switching valve 203 is switched to connect the second pre-control pressure P2 or the third pre-control pressure P3, and output the same to the second inlet of the first shuttle valve 205.

10 In an embodiment, the second switching valve 203 is a mechanical switching valve with a control port; when there is an air source at the control port of the second switching valve, the second pre-control pressure P2 is communicated; and when there is no air source at the control port of the second switching valve, the third pre-control pressure P3 is switched to be communicated with. More specifically, the brake cylinder control module 2 is further provided
15 with an electric control valve 208 for controlling the second switching valve 203 to be switched between the second pre-control pressure P2 (the first inlet) and the third pre-control pressure P3 (the second inlet), wherein an inlet of the electric control valve 208 is connected with the total air 3, and an outlet thereof is connected to the control port of the second switching valve 203. The electric control valve 208 is energized to open, to communicate the total air 3 and the control
20 port of the second switching valve 203, so that the second pre-control pressure P2 communicates to the first inlet of the second switching valve 203 and is outputted to the first shuttle valve 205. The electric control valve 208 is de-energized to close, to cut off the total air 3 and the control port of the second switching valve 203, so that the third pre-control pressure P3 communicates to the second inlet of the second switching valve 203 and is outputted to the first shuttle valve 205.
25 That is, during de-energization, the second switching valve 203 will be automatically switched to communicate with the second inlet (connected to the mechanical three-way valve 204) thereof.

As previously mentioned, the first inlet of the first shuttle valve 205 is connected with the outlet of the first relay valve 103 (that is, connected to the first branch PA1 of the equalizing pipe pressure PA), and the second inlet of the first shuttle valve 205 is connected with the outlet of the
30 second switching valve 203. In addition, an outlet of the first shuttle valve 205 is connected to a first inlet of a second shuttle valve 209, so that a higher pressure in the first inlet and the second

inlet of the first shuttle valve 205 is selected as a fourth pre-control pressure P4 (that is, P4 is a higher pressure between PA1 and P2, or P4 is a higher pressure between PA1 and P3) to be outputted to the first inlet of the second shuttle valve 209.

As an emergency means, the brake cylinder control module 2 is further provided with a relief valve 210 and an emergency booster valve 211; wherein an inlet of the relief valve 210 is connected with the total air 3, and an outlet thereof is connected to an inlet of the emergency booster valve 211. An outlet of the emergency booster valve 211 outputs a fifth pre-control pressure P5 to a second inlet of the second shuttle valve 209. A control port of the emergency booster valve 211 is controlled by the air source from the train pipe 4, so that a pipeline between the relief valve 210 and the second inlet of the second shuttle valve 209 is opened or closed to switch on or off the output of the fifth pre-control pressure P5. When the pressure of the air source from the train pipe 4 is high enough, the emergency booster valve 211 is controlled in a closed state; and when the pressure of the air source from the train pipe 4 drops to a threshold, the emergency booster valve 211 is controlled in an open state, so that the air source from the relief valve 210 reaches the second shuttle valve 209 to serve as the fifth pre-control pressure P5.

As previously mentioned, the first inlet of the second shuttle valve 209 is connected with the outlet of the first shuttle valve 205, and the second inlet of the second shuttle valve 209 is connected with the outlet of the emergency booster valve 211. In addition, an outlet of the second shuttle valve 209 is connected to a control port of a second relay valve 212, so that a higher pressure in the first inlet and the second inlet of the second shuttle valve 209 is selected as a sixth pre-control pressure P6 (that is, P6 is a higher pressure between P4 and P5) to be outputted to the control port of the second relay valve 212. A second pre-control reservoir 213 is provided on a pipeline where the sixth pre-control pressure P6 locates, for storing compressed air to supply an air source as the sixth pre-control pressure P6.

An inlet of the second relay valve 212 is connected with the total air 3, and an outlet thereof is connected to a second inlet of the third shuttle valve 214, so that an amplified sixth pre-control pressure is outputted as a first brake cylinder pressure PB1 to the second inlet of the third shuttle valve 214. The first inlet of the third shuttle valve 214 is connected with the outlet (i.e., the second branch PA2 of the equalizing pipe pressure PA) of the first switching valve 104, and an outlet of the third shuttle valve 214 is connected to a brake cylinder 215, so that a higher pressure in the first inlet and the second inlet of the third shuttle valve 214 is selected as a second brake

cylinder pressure PB2 (that is, PB2 is a higher pressure between PB1 and PA2) to be outputted to the brake cylinder for braking.

It is to be understood that the total air in the present application may refer to a total air at the same position or total airs at different positions (such as branches of one total air), which can both refer to the total air from the main air reservoir of a train. The control system in the present application may be further provided with a plurality of sensors, especially pressure sensors for measuring pressures on different positions to boost or relieve a pressure or give an early alarm and the like, which is understood by the skilled in the art. In addition, energized or de-energized states of the various electric control valves such as the various magnet valves in the present application and the various previously-mentioned sensors can be controlled by a control unit. The control unit might adopt various processors capable of satisfying conditions, such as a CPU, a PLC, an industrial personal computer, a computer and other hardware. By programming and storing programs that is able to realize corresponding functions in a memory, the control unit executes these programs to realize various functions. It is a conventional control means which can be envisioned and can also be understood by the skilled in the art.

A second embodiment of the present application provides a locomotive brake control method, adopting the locomotive brake control system in any embodiments previously mentioned, and the control method comprises at least one of following three states:

(1) Normal working state (as shown in Fig. 1)

In the equalizing pipe control module:

The pressure of the inputted total air 3 is controlled and outputted as the desired first pre-control pressure P1 by the first air-charging magnet valve 101 and the first air-discharging magnet valve 102 through the air charging action and the air discharging action, and the first pre-control pressure P1 is outputted to the first pre-control reservoir 105.

The first pre-control pressure P1 further acts on the control port of the first relay valve 103, the total air 3 is inputted to the inlet of the first relay valve 103, after flow amplification, the equalizing pipe pressure PA is outputted through the outlet of the first relay valve 103, and the first branch PA1 of the equalizing pipe pressure reaches the first inlet of the first shuttle valve 205 of the brake cylinder control module 2.

The first switching valve 104 is de-energized to be in a closed state, so that the second branch PA2 of the equalizing pipe pressure is not supplied to the first inlet of the third shuttle

valve 241.

In the brake cylinder control module:

The pressure of the inputted total air 3 is controlled and outputted as the desired second pre-control pressure P2 by the second air-charging magnet valve 201 and the second
5 air-discharging magnet valve 202 through the air charging action and the air discharging action.

The electric control valve 208 is energized to open, and the total air 3 reaches the control port of the second switching valve 203, so that the second pre-control pressure P2 enters the second switching valve 203 and reaches the second inlet of the first shuttle valve 205.

The first shuttle valve 205 selects a higher pressure between the first branch PA1 of the
10 equalizing pipe pressure and the second pre-control pressure P2, and outputs as the fourth pre-control pressure P4 to the first inlet of the second shuttle valve 209.

When the pressure of the train pipe 4 drops to the threshold, the emergency booster valve 211 is opened, and the fifth pre-control pressure P5 is outputted to the second inlet of the second
shuttle valve 209. The second shuttle valve selects a higher pressure between the fourth
15 pre-control pressure P4 and the fifth pre-control pressure P5, and outputs as the sixth pre-control pressure P6 to the second pre-control reservoir 213.

When the pressure of the train pipe 4 is higher than the threshold, the emergency booster valve 211 is in a closed state; and at this moment, the second shuttle valve 209 only acquires the
fourth pre-control pressure P4, and outputs as the sixth pre-control pressure P6 to the second
20 pre-control reservoir 213.

The sixth pre-control pressure P6 further acts on the control port of the second relay valve 212, the total air 3 is inputted to the inlet of the second relay valve 212, and after flow
amplification, the first brake cylinder pressure PB1 is outputted to the second inlet of the third
shuttle valve 214 through the outlet of the second relay valve 212.

The third shuttle valve 214 outputs the first brake cylinder pressure PB1 as the second brake
25 cylinder pressure PB2, reaching the brake cylinder 215 to achieve braking.

(2) Brake cylinder control module in a fault state (as shown in Fig. 2)

When a fault occurs in the brake cylinder control module, for example, the second
air-charging magnet valve 201 and the second air-discharging magnet valve 202 fail, or the brake
30 cylinder is de-energized.

In the equalizing pipe control module:

The pressure of the inputted total air 3 is controlled and outputted as the desired first pre-control pressure P1 by the first air-charging magnet valve 101 and the first air-discharging magnet valve 102 through the air charging action and the air discharging action, and the first pre-control pressure P1 is outputted to the first pre-control reservoir 105.

5 The first pre-control pressure P1 further acts on the control port of the first relay valve 103; the total air 3 is inputted to the inlet of the first relay valve 103, after flow amplification, the equalizing pipe pressure PA is outputted through the outlet of the first relay valve 103, and the first branch PA1 of the equalizing pipe pressure reaches the first inlet of the first shuttle valve 205 of the brake cylinder control module 2.

10 The first switching valve 104 is de-energized to be in a closed state, so that the second branch PA2 of the equalizing pipe pressure cannot be supplied to the first inlet of the third shuttle valve 214.

The working way of the equalizing pipe control module described herein is similar to or same as the working way of the equalizing pipe control module in the normal working state.

15 In the brake cylinder control module:

The second air-charging magnet valve 201 and the second air-discharging magnet valve 202 fail, so that the second pre-control pressure P2 cannot be normally outputted.

At this moment, the electric control valve 208 is de-energized to be closed, and no air source reaches the control port of the second switching valve 203, so that the second switching valve
20 203 is switched to connect with the mechanical three-way valve 204; the third pre-control pressure P3 is generated by the mechanical three-way valve 204 according to the pressure change of the train pipe 4, and is outputted to the second inlet of the first shuttle valve 205.

The first shuttle valve 205 selects a higher pressure between the first branch PA1 of the equalizing pipe pressure and the third pre-control pressure P3, and outputs as the fourth
25 pre-control pressure P4 to the first inlet of the second shuttle valve 209.

When the pressure of the train pipe 4 drops to the threshold, the emergency booster valve 211 is opened, and the fifth pre-control pressure P5 is outputted to the second inlet of the second shuttle valve 209. The second shuttle valve selects a higher pressure between the fourth pre-control pressure P4 and the fifth pre-control pressure P5, and outputs as the sixth pre-control
30 pressure P6 to the second pre-control reservoir 213.

When the pressure of the train pipe 4 is higher than the threshold, the emergency booster

valve 211 is in a closed state; and at this moment, the second shuttle valve 209 only acquires the fourth pre-control pressure P4, and outputs as the sixth pre-control pressure P6 to the second pre-control reservoir 213.

The sixth pre-control pressure P6 further acts on the control port of the second relay valve 212, the total air 3 is inputted to the inlet of the second relay valve 212, and after flow amplification, the first brake cylinder pressure PB1 is outputted to the second inlet of the third shuttle valve 214 through the outlet of the second relay valve 212.

The third shuttle valve 214 outputs the first brake cylinder pressure PB1 as the second brake cylinder pressure PB2, reaching the brake cylinder 215 to achieve braking.

In this situation, the equalizing pipe control module can keep supplying the first branch PA1 of the equalizing pipe pressure; and at the same time, the mechanical three-way valve 204 can also output the third pre-control pressure P3, thereby achieving double safety.

(3) Second relay valve in a fault state (as shown in Fig. 3)

When a fault occurs in the second relay valve 212, the previously-mentioned sixth pre-control pressure P6 cannot be outputted as the first brake cylinder pressure PB1; at this moment, the equalizing pipe control module 1 controls the first switching valve 104 to be energized to open, so that the second branch PA2 of the equalizing pipe pressure is directly outputted to the first inlet of the third shuttle valve 214 to supply the brake cylinder pressure. A specific embodiment is described as follows:

In the equalizing pipe control module:

The pressure of the inputted total air 3 is controlled and outputted as the desired first pre-control pressure P1 by the first air-charging magnet valve 101 and the first air-discharging magnet valve 102 through the air charging action and the air discharging action, and the first pre-control pressure P1 is outputted to the first pre-control reservoir 105.

The first pre-control pressure P1 further acts on the control port of the first relay valve 103; the total air 3 is inputted to the inlet of the first relay valve 103, and after flow amplification, the equalizing pipe pressure PA is outputted through the outlet of the first relay valve 103.

Wherein, the first branch PA1 of the equalizing pipe pressure reaches the first inlet of the first shuttle valve 205 of the brake cylinder control module 2. The first switching valve 104 is energized to open, so that the second branch PA2 of the equalizing pipe pressure is supplied to the first inlet of the third shuttle valve 214.

In the brake cylinder control module:

The second relay valve 212 fails, so that the first brake cylinder pressure PB1 cannot be effectively outputted.

The third shuttle valve 214 outputs the second branch PA2 of the equalizing pipe pressure as
5 the second brake cylinder pressure PB2, reaching the brake cylinder 215 to achieve braking.

The order of the steps described in the present embodiment is only the description order, and it can be adjusted according to actual demands during actual operation; therefore, the description order does not constitute an absolute limitation on the present application.

By the above-mentioned arrangement, the present embodiment can at least achieve the
10 following functions:

(1) When pressure control faults occur on the second air-charging magnet valve and the second air-discharging magnet valve in the brake cylinder control module, the first branch PA1 of the equalizing pipe pressure can be automatically switched for redundancy control, and the mechanical three-way valve 204 can also be automatically switched for redundancy control.

15 (2) In the brake cylinder control module, the electric control valve 208 is energized to open in normally working state, and is de-energized to be closed in redundantly working state; and when the brake cylinder control module is de-energized, the mechanical three-way valve can also achieve redundancy control on the pressure of the brake cylinder.

(3) The control air source of the emergency booster valve 211 adopts the pressure of the
20 train pipe; and after the pressure of the train pipe is exhausted, the emergency booster valve 211 is automatically opened to output the fifth pre-control pressure P5 to the second shuttle valve 209, thereby supplying a pre-control pressure to the brake cylinder control module.

(4) When the second relay valve 212 fails, the sixth pre-control pressure P6 cannot be outputted as the first brake cylinder pressure PB1, and the equalizing pipe control module
25 controls the first switching valve 104 to be energized to open, so that the branch pressure of the equalizing pipe is directly outputted to the brake cylinder to supply a brake cylinder pressure.

(5) In the present application, regional processing is performed on the functional modules, brake cylinder pressure related functional control is performed in the brake cylinder control module, and equalizing pipe pressure functional control is performed in the equalizing pipe
30 control module. When one of the modules fails, redundancy control is performed by the other one, which ensures normal function of the brake system and improves the availability of the

system. When one of the modules fails, the corresponding module is replaced after overhaul conditions are satisfied, so that the maintainability of the system is improved.

The embodiments are only described as preferred embodiments of the present application, and are not intended to limit the scope of the present application. Various modifications and
5 improvements made on the technical solutions of the present application by ordinary skill in the art without departing from the design spirit of the present application shall fall within the protective scope confirmed by the claims of the present application.

CLAIMS

1. A locomotive brake control system, including a equalizing pipe control module, a brake cylinder control module and a total air; wherein,

5 the equalizing pipe control module includes a first air-charging magnet valve and a first air-discharging magnet valve both connected with the total air and capable of controlling and outputting a pressure of the inputted total air as a desired first pre-control pressure P1 through an air charging action and an air discharging action;

the equalizing pipe control module further includes a first relay valve and a first switching
10 valve; wherein, the first pre-control pressure P1 reaches a control port of the first relay valve; an inlet of the first relay valve is connected with the total air, and an amplified first pre-control pressure is outputted as an equalizing pipe pressure PA through an outlet of the first relay valve; a first branch PA1 of the equalizing pipe pressure PA is connected to a first inlet of a first shuttle valve of the brake cylinder control module by a pipeline; a second branch PA2 of the equalizing
15 pipe pressure PA is connected to an inlet of the first switching valve by a pipeline; and the second branch PA2 is able to be outputted through an outlet of the first switching valve to reach a first inlet of a third shuttle valve of the brake cylinder control module;

the brake cylinder control module includes a second air-charging magnet valve and a second air-discharging magnet valve both connected with the total air and capable of controlling and
20 outputting a pressure of the inputted total air as a desired second pre-control pressure P2 through an air charging action and an air discharging action;

the brake cylinder control module further includes a second switching valve, a mechanical three-way valve and the first shuttle valve; wherein, the second pre-control pressure P2 is connected to a first inlet of the second switching valve;

25 the mechanical three-way valve is a mechanical valve capable of outputting a third pre-control pressure P3; a first inlet of the mechanical three-way valve is connected with a train pipe to be supplied with an air source; and an outlet of the mechanical three-way valve is connected to a second inlet of the second switching valve to output the third pre-control pressure P3;

the second switching valve is configured to be able to switch between the first inlet and the
30 second inlet to select the second pre-control pressure P2 or the third pre-control pressure P3, and an outlet of the second switching valve communicates to a second inlet of the first shuttle valve;

an outlet of the first shuttle valve is connected to a control port of a second relay valve, so that a higher pressure in the first inlet and the second inlet of the first shuttle valve is selected as a fourth pre-control pressure P4 to be outputted to the control port of the second relay valve;

an inlet of the second relay valve is connected with the total air, and an outlet of the second relay valve is connected to a second inlet of the third shuttle valve, so that an amplified fourth pre-control pressure is outputted as a first brake cylinder pressure PB1 to the second inlet of the third shuttle valve;

an outlet of the third shuttle valve is connected to a brake cylinder, so that a higher pressure in the first inlet and the second inlet of the third shuttle valve is selected as a second brake cylinder pressure PB2 to be outputted to the brake cylinder for braking.

2. The locomotive brake control system as claimed in claim 1, wherein, the brake cylinder control module further includes a second shuttle valve, a relief valve and an emergency booster valve; wherein,

the outlet of the first shuttle valve is connected to a first inlet of the second shuttle valve, so that the higher pressure in the first inlet and the second inlet of the first shuttle valve is selected as the fourth pre-control pressure P4 to be outputted to the first inlet of the second shuttle valve;

an inlet of the relief valve is connected with the total air, and an outlet of the relief valve is connected to an inlet of the emergency booster valve; a fifth pre-control pressure P5 is outputted to a second inlet of the second shuttle valve through an outlet of the emergency booster valve; a control port of the emergency booster valve is connected with the train pipe to be supplied with a control air source to open or close the emergency booster valve; and

an outlet of the second shuttle valve is connected to the control port of the second relay valve, so that a higher pressure in the first inlet and the second inlet of the second shuttle valve is selected as a sixth pre-control pressure P6 to be outputted to the control port of the second relay valve.

3. The locomotive brake control system as claimed in claim 2, wherein, the mechanical three-way valve selects an adjustable three-way valve; and a second inlet of the mechanical three-way valve is connected with a working reservoir, and when a pressure of the train pipe changes, the train pipe and the working reservoir are dynamically balanced.

4. The locomotive brake control system as claimed in any one of claims 1-3, wherein, the second switching valve is a mechanical switching valve with a control port; when there is an air source at the control port of the second switching valve, the second pre-control pressure P2 is communicated with; and when there is no air source at the control port of the second switching valve, the third pre-control pressure P3 is switched to be communicated with.

5. The locomotive brake control system as claimed in claim 4, wherein, in the brake cylinder control module, an electric control valve is provided for controlling the second switching valve to be switched between the second pre-control pressure P2 and the third pre-control pressure P3; wherein an inlet of the electric control valve is connected with the total air, and an outlet of the electric control valve is connected to the control port of the second switching valve; and the electric control valve is configured to: when energized, communicate the total air with the control port of the second switching valve so that the second switching valve communicates with the second pre-control pressure P2; and when de-energized, cut off the total air with the control port of the second switching valve so that the second switching valve communicates with the third pre-control pressure P3.

6. The locomotive brake control system as claimed in any one of claims 1-3 and 5, wherein, a first pre-control reservoir is provided on a pipeline where the first pre-control pressure P1 is located, capable of storing compressed air to supply an air source as the first pre-control pressure P1; and an action reservoir is provided on a pipeline where the third pre-control pressure P3 is located, for storing compressed air to supply an air source as the third pre-control pressure P3.

7. The locomotive brake control system as claimed in claim 2 or 3, wherein, a second pre-control reservoir is provided on a pipeline where the sixth pre-control pressure P6 is located, for storing compressed air to supply an air source as the sixth pre-control pressure P6.

8. A locomotive brake control method, adopting the locomotive brake control system as claimed in any one of claims 1-7, and the control method including at least one of the following three states:

(1) normal working state

in the equalizing pipe control module:

the pressure of the inputted total air is controlled and outputted as the desired first pre-control pressure P1 by the first air-charging magnet valve and the first air-discharging magnet valve through the air charging action and the air discharging action, and acts on the control port of the first relay valve; the total air is inputted through the inlet of the first relay valve, after flow amplification, the equalizing pipe pressure PA is outputted through the outlet of the first relay valve; and the first branch PA1 of the equalizing pipe pressure reaches the first inlet of the first shuttle valve of the brake cylinder control module;

the first switching valve is in a closed state, so that the second branch PA2 of the equalizing pipe pressure is not supplied to the first inlet of the third shuttle valve;

in the brake cylinder control module:

the pressure of the inputted total air is controlled and outputted as the desired second pre-control pressure P2 by the second air-charging magnet valve and the second air-discharging magnet valve through the air charging action and the air discharging action;

the first inlet of the second switching valve is communicated, so that the second pre-control pressure P2 enters the second switching valve and reaches the second inlet of the first shuttle valve;

the first shuttle valve selects a higher pressure between the first branch PA1 of the equalizing pipe pressure and the second pre-control pressure P2, and outputs as the fourth pre-control pressure P4 acting on the control port of the second relay valve; and the total air is inputted through the inlet of the second relay valve, and after flow amplification, the first brake cylinder pressure PB1 is outputted to the second inlet of the third shuttle valve through the outlet of the second relay valve;

the third shuttle valve outputs the first brake cylinder pressure PB1 as the second brake cylinder pressure PB2, reaching the brake cylinder to achieve braking;

(2) the brake cylinder control module in a fault state

in the equalizing pipe control module:

the pressure of the inputted total air is controlled and outputted as the desired first pre-control pressure P1 by the first air-charging magnet valve and the first air-discharging magnet valve through the air charging action and the air discharging action, and acts on the control port of the first relay valve; the total air is inputted through the inlet of the first relay valve, after flow amplification, the equalizing pipe pressure PA is outputted through the outlet of the first relay valve; and the first branch PA1 of the equalizing pipe pressure reaches the first inlet of the first shuttle valve of the brake cylinder control module;

the first switching valve is in a closed state, so that the second branch PA2 of the equalizing pipe pressure is not supplied to the first inlet of the third shuttle valve;

in the brake cylinder control module:

the second pre-control pressure P2 is unable to be normally outputted in the brake cylinder
5 control module;

the second switching valve is switched to that the second inlet is communicated, so that the second switching valve is switched to connect with the mechanical three-way valve; and the third pre-control pressure P3 is inputted, and is outputted to the second inlet of the first shuttle valve;

the first shuttle valve selects the higher pressure between the first branch PA1 of the equalizing
10 pipe pressure and the third pre-control pressure P3, and outputs as the fourth pre-control pressure P4 acting on the control port of the second relay valve; and the total air is inputted through the inlet of the second relay valve, and after flow amplification, the first brake cylinder pressure PB1 is outputted to the second inlet of the third shuttle valve through the outlet of the second relay valve;

the third shuttle valve outputs the first brake cylinder pressure PB1 as the second brake cylinder
15 pressure PB2, reaching the brake cylinder to achieve braking; and

(3) the second relay valve in a fault state

in the equalizing pipe control module:

the pressure of the inputted total air is controlled and outputted as the desired first pre-control pressure P1 by the first air-charging magnet valve and the first air-discharging magnet valve
20 through the air charging action and the air discharging action, and acts on the control port of the first relay valve; the total air is inputted through the inlet of the first relay valve, and after flow amplification, the equalizing pipe pressure PA is outputted through the outlet of the first relay valve; wherein, the first branch PA1 of the equalizing pipe pressure reaches the first inlet of the first shuttle valve of the brake cylinder control module; and the first switching valve is in an open state,
25 so that the second branch PA2 of the equalizing pipe pressure is supplied to the first inlet of the third shuttle valve;

in the brake cylinder control module:

the second relay valve fails, so that the first brake cylinder pressure PB1 is unable to be effectively outputted; at this moment, the third shuttle valve outputs the second branch PA2 of the
30 equalizing pipe pressure as the second brake cylinder pressure PB2, reaching the brake cylinder to achieve braking.

9. The locomotive brake control method as claimed in claim 8, wherein, when the brake cylinder control module has the second shuttle valve, the relief valve and the emergency booster valve,

for (1) the normal working state:

5 the first shuttle valve selects the higher pressure between the first branch PA1 of the equalizing pipe pressure and the second pre-control pressure P2, and outputs as the fourth pre-control pressure P4 to the first inlet of the second shuttle valve;

when a pressure of the train pipe drops to a threshold, the emergency booster valve is opened, and the fifth pre-control pressure P5 is outputted to the second inlet of the second shuttle valve; the
10 second shuttle valve selects the higher pressure between the fourth pre-control pressure P4 and the fifth pre-control pressure P5, and outputs as the sixth pre-control pressure P6 acting on the control port of the second relay valve; and the total air is inputted through the inlet of the second relay valve, and after flow amplification, the first brake cylinder pressure PB1 is outputted to the second inlet of the third shuttle valve through the outlet of the second relay valve;

15 when the pressure of the train pipe is higher than the threshold, the emergency booster valve is closed; at this moment, the second shuttle valve only acquires the fourth pre-control pressure P4, and outputs as the sixth pre-control pressure P6 acting on the control port of the second relay valve; and the total air is inputted through the inlet of the second relay valve, and after flow amplification, the first brake cylinder pressure PB1 is outputted to the second inlet of the third shuttle valve
20 through the outlet of the second relay valve;

for (2) the brake cylinder control module in the fault state:

the first shuttle valve selects the higher pressure between the first branch PA1 of the equalizing pipe pressure and the third pre-control pressure P3, and outputs as the fourth pre-control pressure P4 to the first inlet of the second shuttle valve;

25 when the pressure of the train pipe drops to the threshold, the emergency booster valve is opened, and the fifth pre-control pressure P5 is outputted to the second inlet of the second shuttle valve; the second shuttle valve selects a higher pressure between the fourth pre-control pressure P4 and the fifth pre-control pressure P5, and outputs as the sixth pre-control pressure P6 acting on the control port of the second relay valve; and the total air is inputted through the inlet of the second
30 relay valve, and after flow amplification, the first brake cylinder pressure PB1 is outputted to the second inlet of the third shuttle valve through the outlet of the second relay valve;

when the pressure of the train pipe is higher than the threshold, the emergency booster valve is closed; at this moment, the second shuttle valve only acquires the fourth pre-control pressure P4, and outputs as the sixth pre-control pressure P6 acting on the control port of the second relay valve; and the total air is inputted through the inlet of the second relay valve, and after flow amplification, 5 the first brake cylinder pressure PB1 is outputted to the second inlet of the third shuttle valve through the outlet of the second relay valve.

10. The locomotive brake control method as claimed in claim 8, wherein, when the brake cylinder control module has the electric control valve, in (1) the normal working state, the electric control valve is energized to be opened, so that the first inlet of the second switching valve is communicated; and in (2) the brake cylinder control module in a fault state, the electric control valve is de-energized to be closed, so that the second switching valve is switched to that the second inlet is communicated.