Research on Integrated Pneumatic Control Valve Based on Frame Control Brake System of Rail Vehicle

BuDu Xu¹,², *, Xuan Zhang³,², ShiXi Zhang³,³, QingXuan Li⁴,⁴, XiaoYu Zhu⁵,⁵

¹ Zhejiang Ruili air compressor equipment Co., Ltd Wenzhou 325200, China
² Zhejiang Ruili air compressor equipment Co., Ltd Wenzhou 325200, China
³ Zhejiang Ruili air compressor equipment Co., Ltd Wenzhou 325200, China
⁴ Zhejiang Ruili air compressor equipment Co., Ltd Wenzhou 325200, China
⁵ Zhejiang Ruili air compressor equipment Co., Ltd Wenzhou 325200, China

¹, * srl7787@163.com, ²13566141160@163.com, ³zhangshixi31@126.com, ⁴987110094@qq.com, ⁵54992063@qq.com

Abstract: This product is used in the frame control system of railway vehicles. It integrates remote function, anti-skid function and communication function, and highly modularizes the common braking, emergency braking and anti-skid protection functions of railway vehicles.

1. Introduction

that braking distance is an important index to measure the performance of braking system [1-2]. This product integrates the left and right axle anti-skid protection function modules of rail vehicles through the component communication module, and uses the remote module as the carrier to give the air source input to the anti-skid protection function module. At the same time, the remote module and the communication module can be connected with each other to meet the needs of braking relief and impulse limitation.

Implementation:

1) Common braking: When the vehicle needs common braking, electric braking is preferred for common braking, and air braking is supplemented when the electric braking fails or the electric braking force is insufficient to achieve the required deceleration of common braking. Common braking has anti-skid function and is limited by impact limit. Realize two-axle common braking.

2) Emergency braking: When the vehicle needs emergency braking, the braking force is only provided by air, which has anti-skid function but is not limited by impact limit.

3) Communication function: As the air source pressure is required for the two-axle braking of rail vehicles, the communication of the two-axle air passages is realized through the internal communication valve.

4) Anti-skid function: A2, A4, A3 and A5 are solenoid valves matched with anti-skid control valves. By controlling the solenoid valves to turn on and off power, the movement of pistons D, E, F and G can achieve the functions of air charging, pressure maintaining and exhaust, thus realizing brake application and relief to play an anti-skid role.
2. **Structure and working principle**

Figure 1 shows a cross-sectional view after assembly, mainly reflecting the internal structure and working principle of the product.

![Figure 1 Structural schematic diagram](image)

The specific principle is as follows:

2.1 **Remote mitigation function**

2.1.1 *Opening and closing of ventilation system*

The remote release solenoid valve A1 is disconnected when it is not energized, and there is no pressure on the upper plane (big end) of the remote release piston B. The air inlet port of brake air inlet P1 is connected with the lower plane (small end) of remote release piston B, so the remote release piston B moves upward under the action of air pressure, the valve port is open, and the air inlet port of P1 and cavity B1 are connected. At the same time, the spring force of the spring l acts on the upper plane (big end) of the connecting exhaust piston I to make the connecting exhaust piston I move downward, and the valve port is closed. At this time, the connecting exhaust function is closed.

2.1.2 *Cut off and connect exhaust state*

When the remote release solenoid valve A1 is powered on, the air inlet and output ports of the solenoid valve are connected. At this time, there is pressure at the big end and small end of the remote release piston B, but the pressure at the big end of the remote release piston B is the air supply pressure of the solenoid valve. Because the air supply port of the solenoid valve is the air source, the total air pressure is greater than the brake air supply pressure, so the remote release piston B moves downward, the valve port is closed, and the air supply pressure is cut off. Downstream air supply, brake air inlet P1 cavity and B1 cavity cut off. At the same time, a part of the air source at the output port of the solenoid valve will be diverted to the lower plane (small end) of the Unicom exhaust piston I, so that the Unicom exhaust piston I can overcome the spring force of the spring l acting on the upper plane (large end) of the Unicom exhaust piston I, and the Unicom exhaust piston I can move upward to empty the pressure of E1 and F1 cavities, so as to realize remote release, and achieve the function of connecting exhaust through the Unicom exhaust port P7.

2.2 **Impulse limiting function**

The B1 cavity of the remote release valve is communicated with the small end of the impulse limiting piston C. At the same time, B1 cavity will block m to limit the output pressure of C1 cavity.
2.2.1 **Emergency braking**
During emergency braking, the emergency braking limit solenoid valve A7 is powered on, the air inlet and output ports of the solenoid valve are cut off, and there is no air pressure at the big end of the impulse limit piston C. Under the action of the air pressure in the B1 cavity, the impulse limit piston C moves upward, and the valve port is opened. The pressure of chamber B1 enters into chamber C1 at the outlet of braking restriction through the valve port and M flow, and leads to the downstream to realize emergency braking.

2.2.2 **Impulse limitation**
During the service braking, the emergency brake limit solenoid valve A7 loses power, and the air inlet and output ports of the solenoid valve are connected, so the impulse limit piston C moves downward under the action of the air pressure of the solenoid valve until the valve port is closed. The pressure air in chamber B1 can only flow to the downstream through plug M. Because the flow rate of C1 cavity is controlled by adjusting the inner diameter of plug m, the impulse is limited by adjusting the inner diameter of plug M.

In the actual operation of rail vehicles, according to the needs of application, the A7 solenoid valve can be cancelled and the cover plate can be added instead, which is equivalent to A7 being in the power on state. Therefore, there is no flow restriction in service braking and emergency braking, and the impulse restriction function is cancelled.

2.3 **Double cylinder connection selection**

2.3.1 **Double cylinder connection**
When the connecting solenoid valve A6 loses power, the air pressure of E1 cavity acts on the lower end of connecting piston h. Therefore, the connecting piston h moves upward under the action of air pressure, so that the valve port of piston h is opened, and E1 cavity and F1 cavity are connected with each other, that is, the one axle and two axle brake cylinders are connected.

2.3.2 **Two independent cylinders**
When the connecting solenoid valve A6 is powered on, the solenoid valve supplies air to the big end of the connecting piston h. Because the total air pressure of the solenoid valve is greater than the braking air supply pressure, the connecting piston h moves downward, and the valve port is closed, so that the E1 cavity and F1 cavity are cut off from each other, that is, the one axle and two axle brake cylinders are independent.

2.4 **Antiskid function**
Keep the solenoid valve A6 in the power on state to cut off the air circuit of the first axle and the second axle brake cylinder.

2.4.1 **One axle anti slip air charging**
During air charging, both the first axle air charging solenoid valve A2 and the first axle exhaust solenoid valve A4 are in the power-off state. Under the action of the internal air circuit of the solenoid valve, the valve port D of the first axle exhaust piston is closed, the valve port e of the first axle air charging piston is opened, and the first axle brake cylinder is in the air charging state, that is, the air source is output from the first axle brake port P3.

2.4.2 **Anti skid and pressure maintaining of the first axle**
During pressure maintaining, the first axle air charging solenoid valve A2 is powered on, and there is air pressure at the big end of the first axle air charging piston E. Since the area of the big end of the piston is larger than that of the small end, the pressure generated by the big end is also greater than that of the small end, so the first axle air charging piston e moves downward, the valve port is closed, and
the air supply to the first axle brake cylinder is cut off, so that the first axle is in the pressure maintaining state.

2.4.3 **Anti skid exhaust of first axle**
When exhausting, both the first axis charging solenoid valve A2 and the first axis exhaust solenoid valve A4 are in the power on state, and the gas pressure at the large end of the first axis exhaust piston D is discharged with the exhaust port of the first axis exhaust solenoid valve A4. As the first axle charging solenoid valve A2 is in the power on state, there is air pressure at the big end of the first axle charging piston e, the charging piston e moves downward, and the valve port is closed to cut off the air supply to the first axle brake cylinder; at the same time, the air source at the big end of the first axle charging piston e is drained to the small end of the first axle exhaust piston D, so that the first axle exhaust piston D moves upward, and the valve port is opened, so that the first axle brake cylinder exhausts with the first axle brake exhaust port P5.

2.4.4 **Two axle anti-skid air charging**
During air charging, both the two axis air charging solenoid valve A3 and the two axis exhaust solenoid valve A5 are in the power-off state. Under the action of the internal air circuit of the solenoid valve, the valve port g of the two axis exhaust piston is closed, the valve port F of the two axis air charging piston is opened, and the two axis brake cylinder is in the air charging state, that is, the air source is output from the two axis brake port P4.

2.4.5 **Two axle anti slip and pressure maintaining**
When maintaining pressure, the second axle air charging solenoid valve A3 is powered on, and there is air pressure at the big end of the second axle air charging piston F. because the area of the big end of the piston is larger than that of the small end, the pressure produced by the big end is also greater than that of the small end, so the second axle air charging piston f moves downward, the valve port is closed, and the air supply of the second axle brake cylinder is cut off, so that the second axle is in the pressure maintaining state.

2.4.6 **Two axis anti skid exhaust**
When exhausting, both the two axis charging solenoid valve A3 and the two axis exhaust solenoid valve A5 are in the power on state, and the gas pressure at the big end of the two axis exhaust piston G is discharged with the exhaust port of the two axis exhaust solenoid valve A5. As the second axle air charging solenoid valve is in the power on state, there is air pressure at the big end of the second axle air charging piston F, the second axle air charging piston f moves downward, and the valve port is closed to cut off the air supply to the second axle brake cylinder; at the same time, the air source at the big end of the second axle air charging piston f is drained to the small end of the second axle exhaust piston g, so that the second axle exhaust piston g moves upward, and the valve port is opened, so that the second axle brake cylinder exhausts with the first axle brake exhaust port P6.

2.5 **Automatic reset**
The brake air inlet P1 is cut off. When the pressure of the first axle and the second axle brake cylinder is drained, if the air supply of the main solenoid valve inlet P2 stops or the first axle charging solenoid valve A2 and the second axle charging solenoid valve A3 are in the power-off state, the first axle exhaust piston D and the second axle exhaust piston g move downward under the action of the corresponding spring JK spring force, the valve port is closed, and the first axle and the second axle exhaust function is cut off, The internal state of the integrated brake valve returns to the charging mode.
3. Research and development process

1. This integrated brake valve is developed on the existing technology of a series of single frame-controlled valves in our company. Its core structure remains unchanged, its performance is quite stable and its reliability is extremely strong. The car-controlled brake system, that is, one brake control unit controls two bogies passing through one car, is changed to the frame-controlled brake system, that is, one frame-controlled integrated brake valve controls one bogie. When the product fails, only one bogie fails, reducing the impact on the vehicle and reducing the failure rate by 50%[3-5].

2. This integrated brake valve integrates multiple single frame control valves into one main valve body, saving space, reducing weight and realizing the purpose of lightweight. Due to high integration and one bogie corresponds to one brake valve, it can be installed on bogie accessories, thus shortening the pipeline distance and air consumption of rail vehicles, further shortening the braking response time, which is faster and more sensitive than the traditional braking response.

3. The braking force of the brake valve on the bogie can be adjusted according to the load pressure required by each bogie, which is more accurate than the braking force of the car-controlled control car.

4. Conclusion

This kind of integrated brake valve is a brand-new product designed for the brake system by integrating the existing technology development of frame control valve in a relatively short period of time. On the basis of the original function of a single valve, the purpose of integrated control and structural lightweight is realized, which is in line with the development trend of the market.

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