Research on silent steady flow quick closing check valve for rail vehicle

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Abstract: A kind of air valve which can prevent gas backflow is used in the track air supply system. Check valve is the basic component of fluid control engineering, which is widely used. It plays a role in determining the direction of fluid flow, protecting other fluid machinery and pipeline safety by preventing the reverse flow of fluid [¹]. For example, drilling tool check valves commonly used in oil fields include arrow type valve, float valve and input type check valve [²-³]. The check valve developed by our company is mainly used for gas medium, suitable for high-pressure gas transmission, and plays the role of preventing gas backflow.

1. Introduction

The check valve has the following performances: ① prevent medium backflow; ② prevent pump and its driving motor from reversing; ③ prevent medium in the container from discharging; ④ it can increase the pressure when it is used in the auxiliary system; when it exceeds the specified pressure, it can supply the pressure in the pipeline of the main system, and it is often used in the air brake system of various locomotives [⁴]. However, in the process of selection, it is necessary to avoid that the pressure difference is not considered Diameter and other problems, can not meet the process requirements, resulting in valve leakage or even failure [⁵]. When the air pressure at the input port of the system is greater than that at the output port, and the pressure difference reaches the predetermined value (the predetermined value is determined by the elastic force of the selected compression spring), the check valve will automatically open the channel, and the inlet air will flow to the outlet port for output. When the pressure difference between the input port and the output port is less than the predetermined value, the check valve will close in time. As the sealing surface of the valve adopts the extrusion seal between the valve vulcanization surface and the valve port, the air flow from the air outlet can not be output to the air inlet in the open or closed state of the check valve, so as to achieve the air flow check function. At the same time, in order to improve the stability and service life of the spring, the stainless steel spring is used to strengthen the stability of the check valve.
2. Structure and working principle

As shown in Figure 1, the check valve is mainly composed of five parts: input port A, output port B, screw cap 1, valve body 8, spring 3, valve seat 5 and vulcanization valve assembly 6.

Structure description:
The left threaded port of valve body 8 is air inlet A, and the right threaded port is output B.
Assembly logic: This product consists of parts 1 ~ 9. The specific assembly process is as follows:
1. The valve vulcanization assembly 6 is composed of vulcanization skeleton 9 through rubber vulcanization. In order to ensure that both sides of vulcanization skeleton 9 are covered by rubber, the vulcanization assembly 9 is placed in the middle of valve vulcanization assembly 6. At the same time, the valve vulcanization assembly is shown in Figure 1. The outer circle of vulcanization skeleton 9 is not completely covered by rubber, and the outer edge can ensure the normal flow of gas.
2. Place the valve vulcanization assembly 6 in the inner groove of the valve seat 5 (the smooth surface of the valve vulcanization assembly is outward), and the snap 7 is designed to be notched, so that the snap can be squeezed to reduce the outer circle. Place it on the snap groove of the valve vulcanization assembly to prevent the valve vulcanization assembly 6 from falling off and play the role of movable limit, as shown in enlarged Figure 2.

Figure 1 structure diagram

Figure 2 partial enlarged view
3. Rivet the bushing 4 at the screw sleeve 1, and assemble the O-ring 2 to the screw sleeve 1 (O-ring groove) to form a whole.

4. Put the valve vulcanization assembly 6, valve seat 5, buckle 7 assembly into the valve body 8, and the rubber smooth surface of the valve vulcanization assembly 7 faces the valve port of the valve body 8.

5. Place the spring 3 on the valve vulcanization assembly 7 and screw the integral part of the screw sleeve 1 into the valve body 8.

working principle:

1. Initial opening

The spring force generated by spring 3 acts on the upper end face of valve vulcanization assembly 6 to make the valve move downward. At this time, the valve is closed and the product has no output; When the inlet port a is filled with air and the inlet pressure is gradually increased, the air pressure generated by the lower end face of the valve vulcanization assembly 6 will continue to increase and the direction will be upward. If the pressure is greater than the spring force, the valve will open and the product will have output. In order to ensure the tightness, O-ring 2 is installed at the screw sleeve 1 and valve body 8 for sealing to prevent the product from air leakage.

2. Slowly open the fitting state

After the valve vulcanization assembly 6 and the valve port are opened, the valve vulcanization assembly 6 moves upward under the action of air pressure. Because the gap between the valve vulcanization assembly 6 and the valve seat 5 is small, the valve vulcanization assembly 6 and the valve seat 5 will reach the bonding state in a short time. Because the upper end face of the valve vulcanization assembly 6 is made of rubber material, the valve vulcanization assembly 6 is made of rubber. When the valve vulcanization assembly 6 and the valve seat 5 are bonded, the bonding surface will reach the sealing state, so that the internal volume C enclosed by the valve seat 5, the valve vulcanization assembly 6 and the screw sleeve 1 forms a closed environment. Under the action of the spring force and the back pressure formed by the sealing environment, the resistance of the valve vulcanization assembly 6 increases rapidly in the process of opening and rising, and the output flow is limited at this time. This state can be defined as the slow opening state, as shown in Figure 3.

![Figure 3 slow on fit](image-url)

3. Slowly open and release state

It can be seen from the enlarged figure in Fig. 3 that the air pressure continuously acts on the lower end face of valve seat 5. When the valve seat 5 overcomes the back pressure formed by the sealing environment under the action of air pressure, the valve seat 5 will move upward, and the valve vulcanization assembly 6 not only has the back pressure formed by the sealing environment, but also has spring force, so it cannot move upward, resulting in the loosening of the joint surface between the valve vulcanization assembly 6 and valve seat 5. At this time, as shown in Fig. 4, the gas will enter the internal chamber C through the loose gap between the valve vulcanization assembly 6 and the valve seat 5 assembly. Since the spring force has been acting on the valve vulcanization assembly 6, when
the valve seat 5 moves upward until the buckle 7 and the vulcanization framework 9 fit, the rising resistance increases again due to the spring force, The output flow is limited again, and this state can be defined as the slow opening and releasing state, as shown in Figure 4.

It can be seen from Figure 4 that the gas will enter into the internal chamber C through the loose gap between the valve vulcanization assembly 6 and the valve seat 5 assembly. With the continuous increase of the gas pressure in the internal chamber, the valve seat 5 will reach the upper and lower gas pressure balance state, and the valve seat 5 will be suspended (at this time, although the valve seat 5 can not move upward, it is different from the third point, The third stop mode is caused by the spring force.)

Since the air inlet is facing the lower end face of valve vulcanization assembly 6, the gas pressure exerted by the lower end face of valve vulcanization assembly is the maximum. Under the action of gas pressure, the valve vulcanization assembly will move upward again until the valve vulcanization assembly 6 and valve seat 5 fit together again, as shown in Figure 5. When the output flow is limited again, this state can be defined as the state of slow opening and reclosing.

To sum up, the whole process of the slow opening state is that the valve vulcanization assembly 6 and valve seat 5 are in the bonding, loosening, re bonding and repeated circulation.

When the valve seat 5 contacts the bottom of the screw sleeve 1, the product reaches the maximum opening, the corresponding opening flow also reaches the maximum value, and the spring force also reaches the maximum value. At the maximum opening, the inlet and outlet air pressure will be equal.
Under the action of internal air pressure and spring force, the valve vulcanization assembly 6 and valve seat 5 will fall back to the limit position of buckle 7, as shown in Figure 6.

![Figure 6 maximum opening](image)

6. **Quick return to close**

When the height of valve vulcanization assembly 6 is fully open, if the pressure of air inlet a is rapidly reduced, the pressure of upper end face of valve vulcanization assembly 6 is far greater than that of lower end face. Under the joint action of spring force, the product will quickly return to seat until the valve port is closed. Because valve vulcanization assembly 6 and valve seat 5 are combined into an effective assembly through buckle 7, When the valve vulcanization assembly 6 is quickly seated, the seating force drives the valve seat 5 to move together through the buckle 7, and the internal parts return to the initial state, as shown in Figure 7.

![Figure 7 quick return](image)

7. **Check function**

When the check valve is back closed, the output pressure acts on the upper end face of valve vulcanization assembly 6 and valve seat 5, which increases the valve adhesion force. At this time, the output B cannot return to the air inlet A.

8. **Life extension**

In order to improve the service life of the product, the transition of bushing 4 is added at the screw sleeve 1. The material of bushing 4 is H59, and the material of valve seat is polytetrafluoroethylene.
The self-lubricating property of polytetrafluoroethylene and wear resistance of H59 brass can effectively improve the service life of the product. At the same time, polytetrafluoroethylene is a plastic material, which can further reduce the movement noise.

3. Research and development process
The check valve is developed on the basis of the existing one-way valve of our company. Because the one-way valve has no fixed opening pressure value, the opening pressure value of the check valve can be determined according to the selected compression spring, so as to realize the valve opening at a specific pressure value with high precision. The check valve is of piston type structure with stable performance index. In order to increase the wear resistance and reduce the noise of the valve, the vulcanization component of the valve is vulcanized with rubber, and the PTFE guide valve seat is added. By changing the clearance between the vulcanization component and the valve seat, the opening height of the valve vulcanization component is restricted accordingly, so that the product can be opened smoothly, the output flow is balanced, and there is no vibration.

4. Conclusion
Zhejiang Ruili air compressor equipment Co., Ltd. and Ruili group Ruian Auto Parts Co., Ltd. are market-oriented and user-oriented, integrating the existing one-way valve technology development in a relatively short period of time, and designing a new product for the brake system, which retains all the functions of the original one-way valve, improves the product precision and increases the opening pressure value. The utility model has the advantages of smooth opening, no noise, more safe and controllable in practice, and substantially improves the reliability of the vehicle pneumatic braking system.

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