Research on double tower dryer based on air brake system of rail vehicle

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Abstract: as we all know, in the air brake system of rail vehicles, the air usually contains moisture. In order to solve this problem, the common air dryer can effectively dry the compressed air and thoroughly remove the moisture of the braking system. At present, the dryer used in vehicles has many disadvantages in logic control. The efficiency, service life and air resistance of the dryer do not meet the goal of smaller volume and higher parameter index, so a more excellent dryer is urgently needed.

1. Introduction

In the compressed air equipment, the risk of Moisture Corrosion and freezing in the compressed air will lead to the failure and premature wear of the pneumatic device. There is always water vapor in the atmosphere. As long as water exists in the form of vapor, it is always combined with the air. Until it exceeds the saturation limit (= 100% air relative humidity), water will fall in the form of raindrops, fog or snow.

It can be seen from the saturation curve in Figure 1 below that the saturation limit varies with the temperature. With the increase of temperature, the air can absorb more moisture. This shows that: in the compression process of the compressor, water will not condense due to the rise of temperature; Only when the compressed air is re cooled in the secondary cooler, the water will be condensed.
X 100% air relative humidity Y air temperature (°C) Z absolute water content (g / M³)

Figure 1 saturation curve

Only when the air in the compressed air equipment is dry enough to keep the relative humidity below 35%, can the compressed air device work reliably and economically. Below this critical humidity, atmospheric corrosion will not occur, even if there are so-called corrosion inducing agents such as acids in the air.

The above-mentioned double tower dryer works according to the cooling regeneration adsorption method, which has proved to be the most effective and economical method, especially in rail vehicles.

This method is based on the following physical process: the moist compressed air passes through a desiccant (adsorbent) made of aluminosilicate, which has a particularly large inner surface due to its molecular structure, thus absorbing water vapor from the air flowing through. Compared with other desiccants, the outstanding advantage of this desiccant is that it is insensitive to oil. The selected silicate pore is uniform, and its size is just enough to absorb water molecules.

At the same time, the design type is with heater, so that it can adapt to all existing service conditions in a large range.

In the application field of rail transit, in order to realize uninterrupted gas supply for downstream gas equipment, almost all adsorption dryers are designed into double tower or even multi tower structure. When one tower "adsorbs and dries" compressed wet air, the other tower "desorbs and regenerates" adsorbent synchronously, and the working state of the two towers automatically changes after a set cycle [1].

At present, in the air source system of rail vehicles, the air from the compressor contains a lot of water vapor, which needs to be dried before entering the air reservoir, and then provides clean and dry compressed air for the subsequent system. If the dryer fails, a large amount of water will be mixed in the whole air circuit, which will seriously affect the normal operation of various parts of the air, such as the brake system, bagpipes, door system, suspension system, etc., and may corrode some parts. If it is at low temperature, icing may occur, causing greater risk. At the same time, the dryer used in the vehicle has many disadvantages in logic control. The efficiency, service life and air resistance of the dryer do not meet the goal of smaller volume and higher parameter index, so a more excellent dryer is urgently needed.

At the same time, the traffic adsorption dryer is a typical "mechanical electrical control" system, which is operated by the traditional mechanical pneumatic valve and electromagnetic pneumatic valve under the action of electronic control center. With frequent and regular switching, the process will
inevitably have hidden trouble. Therefore, based on the fail safe guidance strategy, the rail transit braking system generally monitors the process state of the adsorption dryer, and monitors the pressure change of the adsorption tower or regeneration tower through the pressure sensor or pressure switch. The controller or vehicle electronic brake control unit will collect the pressure signal in real time and judge the state, and finally output the fault signal in the form of high level [2].

In order to meet the design requirements of the above double tower dryer, our company switches the left and right towers on the basis of the original reason by controlling the air inlet valve with solenoid valve. They use sliding valve stem. Compared with it, we have larger diameter and higher reliability. Similarly, our left and right towers control valves through solenoid valves to realize exhaust. Compared with them, we have larger diameter and higher reliability. We have added the function of pressure indicator, which is mechanical and can be observed by naked eyes. When the left and right towers are switched, the indicator will bulge and retract repeatedly. During the maintenance of the drying tower, it is also necessary to indicate that there is no pressure in the tower when the indicator retracts. When it comes to the maintenance of the air drying device, we should start with the monitoring of the water vapor content in the braking system, which is just the so-called prevention [3-4]. In contrast, we add the heater, temperature sensor, pressure sensor and other mechanisms, which are controlled, monitored and alarm feedback through the controller. At the same time, we through the single-chip microcomputer and its auxiliary power supply circuit, combined into a controller, small size, full function. Its own timing function can realize the switching between left and right towers, which is the basic function of the product. It can also determine the external temperature and control the heater on and off. It can also monitor whether the timing cycle is accurate, whether the working current of the solenoid valve is normal, and whether the opening and closing of the heater is accurate. If there is any abnormality, the corresponding alarm will be sent out.

2. Structure and working principle

The basic composition of the double tower dryer is shown in Figure 2, including input port 11, input port 12, output port 21, output port 22 and exhaust port 31, exhaust port 32, etc.

![Figure 2 structure principle](image)

The product includes intake valve a, drying cylinder B, pressure indicator C, exhaust valve D, check valve e, pre control valve f, heater g, solenoid valve h, controller L, temperature sensor J,
pressure sensor K and other components. Except for pre control valve f, controller L and temperature sensor J, each component has two sets.

After the air is condensed and filtered, the water droplets in the air entering the drying unit have been greatly reduced, but the air is still saturated and humid, and water molecules exist in the air in the form of saturated water vapor; At this time, the air will enter the drying tower and be adsorbed by contacting with the adsorbent bed, thus reducing the humidity of the flowing air. The two drying towers are switched by two switching solenoid valves.

After drying, a certain proportion of compressed air enters into the regeneration tower through a regeneration hole, flows through the adsorbent bed, and is discharged into the atmosphere through the passage of the exhaust valve. During the reverse flow of dry air into the atmosphere, the volume of compressed air will expand significantly due to the reduction of air from compressed state to atmospheric pressure. In the process of pressure reduction, the water molecules on the adsorbent will separate from the adsorbent and be discharged to the atmosphere with the air through the passage of the exhaust valve. The adsorbent will return to the "dry" state. This process is what we call "regeneration".

The adsorption / regeneration cycle of two drying towers is controlled by an electronic timing circuit. At the beginning of the cycle, the wet air from the upstream enters the adsorption tower, and the dry air is blowed back to the atmosphere in the regeneration tower.

The specific working principle is as follows:

For the convenience of describing the working principle, it is assumed that only input port 11 and output port 21 are connected, and input port 12 and output port 22 are blocked with plugs.

2.1 The air enters through the inlet port 11 and passes through the inlet valve A. generally, the inlet valve A is open, and the air flow is output to the drying cylinder B. the drying cylinder B is equipped with a disturbing metal pipe and molecular sieve. After the disturbing flow, the air flow is uniform, and then the molecular sieve is dried, and then the filter paper is used for filtering, and then the middle gas pipe is used to reach the check valve e, and the air pressure reaches a certain value. The check valve e is opened and the air flow reaches the output port to complete the air flow output.

2.2 When the pressure at the lower end of the pre control valve reaches a certain value, the valve is opened and the air flow reaches the lower end of the solenoid valve h. If the solenoid valve h is powered on, the air flow reaches the closing chamber of the piston a of the inlet valve and the opening chamber of the piston D of the exhaust valve. At this time, the inlet valve A is closed, the exhaust valve D is opened, and the regeneration air flow is discharged.

2.3 Before reaching the check valve e, a part of the air flow dried by drying cylinder B is diverted to another drying cylinder. The air flow moves from the middle pipe of the drying cylinder from the bottom to the top, and then moves from the upper end of the molecular sieve to the lower end, blowing out the adsorbed water in the molecular sieve, reaching the exhaust valve D and discharging from the exhaust port. This split flow can meet the design requirements of regeneration gas consumption of the cylinder by changing the diameter.

2.4 The controller L controls the power on and power off of the solenoid valves H1 and H2. When H1 is powered on, the solenoid valve opens. At this time, part of the air inlet at the B1 end of the drying cylinder is closed and the exhaust is opened. That is to say, the B1 end of the drying cylinder is not dry and is in the state of molecular sieve regeneration. Conversely, when H2 is energized, so is the function.

2.5 The working mode of the controller L can be designed freely according to the needs of different customers, lines and functions, and then the controller will give different working instructions to the solenoid valves H1 and H2.
2.6 Heater G1 and G2 are installed next to two exhaust valves D respectively. The product is equipped with temperature sensor J. When the temperature reaches the set value, the heater starts to work through the control of controller L. When the temperature reaches the set value, the heater stops working.

2.7 The pressure sensor K is installed at the downstream of the solenoid valve h, which is used to monitor whether the working mode of the solenoid valve h is normal, that is, to judge whether the left and right tower switching mode of the double tower dryer is normal.

2.8 When the heater G is working, when the working mode of the pressure sensor K is abnormal, when the switching mode of the solenoid valve h is abnormal, and the current is abnormal, the controller L will send different signals to the outside world.

2.9 The controller L has the function of memory. When necessary, it can read out the total working time of the dryer, the total switching times of the solenoid valve, and the working details in a long period. 10. The pressure indicator C1 is that when there is air pressure in the drying tower, the top rod will pop up. When there is no air pressure, the top rod will automatically retract. It is used to identify the working conditions of the left and right towers and to ensure the safe replacement.

3. **Control system of transfer mechanism**
   The control unit is connected with the compressor at the same time. The control device controls the closing and closing time of the electromagnet for the valve according to a fixed procedure. After idling or shutting down the compressor, the control device will store the actual state of switching on, and continue to count when it is switched on again. Thus, the desiccant to be regenerated can be completely dried without oversaturation due to delaying the conversion cycle.

4. **Conclusion**
   Double tower air dryer is a brand new product developed and designed by Zhejiang Ruili air compressor equipment Co., Ltd. and Ruili group Ruian Auto Parts Co., Ltd. facing the market and users, and integrating the existing air dryer technology in a relatively short time. It retains all the functions of the original dryer and integrates the control system into one. When the conversion unit is abnormal, the double tower air dryer has the advantages of low cost, low cost and low cost, There is always a drying tower to supply compressed air.

**References**

[1] WANG Hai-feng, Application of double tower air dryer on urban rail vehicles [J]. Journal of Dalian Jiaotong University, 2014, 35 (2), 29-32.

[2] He Xiaojun, Long Huawei. Brief analysis of working state monitoring of twin-tower dryers for urban rail vehicles [J]. Technology and Market, 2013, 20 (5); 74-75.

[3] ZHANG Guihua, SHU Tongtai, Gap of Freight Car Wheel Tread Scratch [J]. Railway Rolling Stock, 2010 (5); 32-34.

[4] Wang Xiaodong, Braking System of Guangzhou Metro Line 4 Metro Vehicles [J]. Rolling Stock, 2010 (11); 18-22.