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Optimal design of XJFH-5×35 pneumatic winch valve with extremely low temperature resistance

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Abstract
Low temperature often makes pneumatic winch valves appear stuck, leakage and other failures, in this paper, the assembly clearance between valves parts of pneumatic winch is redesigned by optimizing design and calculating by empirical formulas, to ensure good performance of valve of distribution system at extremely low temperature. It is proved that the redesigned valves have excellent performance, good air tightness and low temperature resistance.

Keywords: *Pneumatic winch, Valves, Low temperature, Assembling clearance*

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I. INTRODUCTION

As the driving device of the main hoisting equipment, the pneumatic winch can work safely and reliably in flammable and explosive environment, and can adapt to the harsh working environment. It is used in mines, oil drilling platforms, pipeline laying, bolt loading and unloading, etc. The industry has been widely used. Extremely low temperature pneumatic winch refers to a pneumatic winch that works in an extremely low temperature environment of -65℃. At present, the general applicable conditions for pneumatic winches produced at home and abroad are working environments with a temperature of not less than -20℃, which cannot meet the requirements of the extremely cold regions, especially the Russian market, and with the increase of exploration and development activities in the Arctic and Antarctic, also need pneumatic equipment that can adapt to the extremely low temperature in these areas.

The valve is the key component of the pneumatic winch, which directly affects the working performance and reliability of the pneumatic winch, and the valve core is the core part of the valve body of the air distribution system. At extremely low temperature, the working performance and reliability of the valve core are affected. Determines the performance and reliability of the entire system. This paper optimizes the design of the assembly gap between the valve body and the valve core of the XJFH-5×35 pneumatic winch (as shown in Figure 1), so that it has the ability to work well in extremely low temperature environments and ensures the pneumatic winch Performance in extremely low temperature environments.

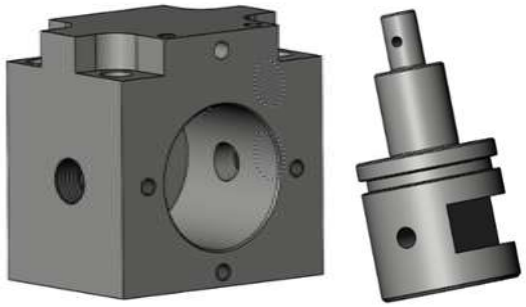
1.1The development of simulation target vehicles

The development of simulated target vehicles is constantly improving with the testing requirements of active safety technologies including AEB systems. Some OEMs and suppliers, such as Continental and Bosch, were the first to carry out related research and development [6]. With the advancement of technology, the simulation test target vehicle has developed from the initial static profiling target vehicle to the high simulation test target vehicle with dynamic performance and intelligence.

Figure 1: XJFH-5×135 pneumatic winch

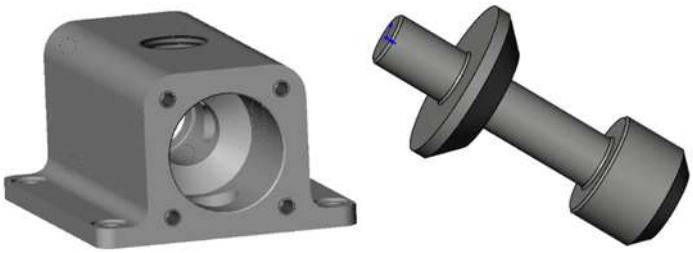
1.2Pneumatic winch air distribution system

This article mainly focuses on the optimization design of the key manual valve, main valve, air supply valve, reversing valve, and distribution valve of the pneumatic winch air distribution system, as shown in Figures 2, 3, and 4 [1]. The valve body and valve core of these valves have a relatively rotating mating surface. The gas sealing performance between the valve hole on the valve body and the valve core directly affects the air distribution efficiency of the air motor, and indirectly affects the output speed and the output speed of the air motor. Torque, when a completely sealed oil film is formed between the valve hole of the valve body and the valve core, the amount of gas leakage is minimized.



a) Valve body b) Valve core

Figure 2: Manual valve structure diagram



a) Valve body b) Valve core

Figure 3: Main valve structure diagram

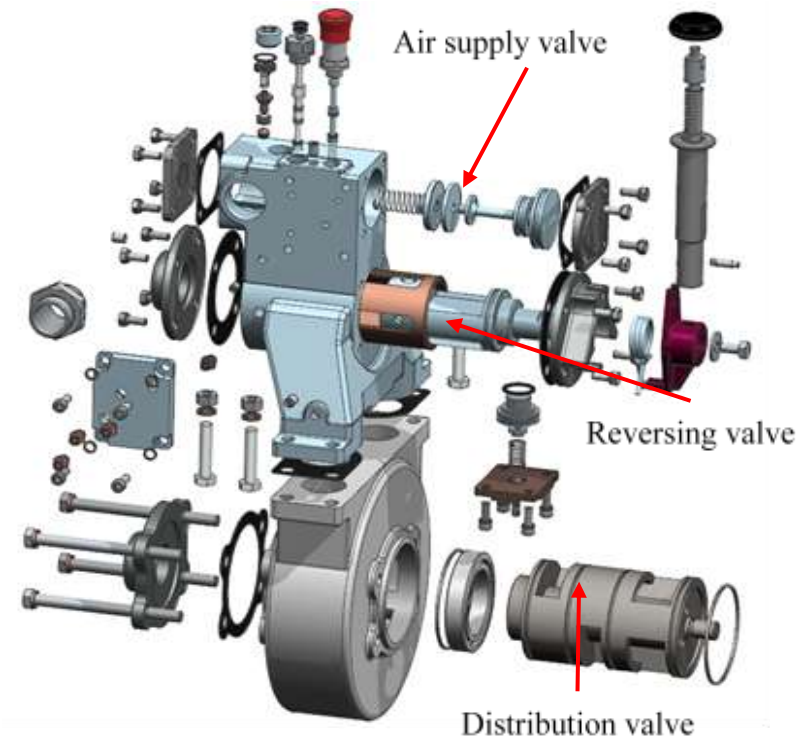


Figure 4: Air distribution system

II. ANALYSISANDMEARSURES

In the low temperature environment, the internal structure of the material will change to a certain extent, and then the volume of the metal will change. The shrinkage of the metal entity may cause the two entities that are moving with each other to become stuck. Both the valve body and the valve core will shrink in a certain amount in a low temperature environment, resulting in a smaller diameter. When the reduction value of the valve hole diameter is greater than the reduction value of the valve core diameter, the matching clearance becomes smaller. When the fit clearance is less than the thickness of the oil film, the movement tendency of the valve core will inevitably destroy the oil film, forming semi-dry friction or dry friction, thereby affecting the movement of the valve core. When completely dry friction is formed, the valve hole and the valve core will become stuck.

Another important reason that causes the valve core and the valve hole to be stuck is that when the matching gap becomes smaller, the sensitivity of the gas distribution valve and the distribution valve to the solid impurities in the gas increases. The solid impurities in the valve body and the valve core did not get stuck. When the matching clearance is smaller than the size of the pollutant particles, the chance of getting stuck is doubled.

The main measures to prevent the valve body and spool from jamming are:

(i) Reasonably choose the fit clearance

The research results at home and abroad show that for the valve body working above -25℃, the fitting clearance does not need to be considered, but for the valve body working below this temperature, the fitting clearance of the valve body increases according to the working conditions of its use.

(ii) Try to use a first-level concentric valve body structure

Multi-stage concentric valve body structure, due to the unevenness of the gap change between the various levels at low temperature, it is easy to cause the valve body to jam, so it is necessary to avoid the use of multi-stage concentric hydraulic valves.

(iii) Choose a reasonable combination of valve body and valve core materials

(iv) Scientific control of gas source impurity content

The extremely low temperature air motor generally works in a difficult environment. In a low temperature environment, the fitting clearance between the valve body parts becomes smaller, making it more sensitive to impurities in the air source. Therefore, it is necessary to control the type and quantity of impurities in the gas source.

In this paper, the assembly size of the valve body and the valve core is changed to optimize the working performance of the pneumatic winch valve at low temperature, so that the existing products can be simply reprocessed to meet the requirements for use in extremely low temperature environments.

III. ASSEMBLEGAPCALCULATE

The research results at home and abroad show that for the valve body that works above -25℃, the fitting clearance does not need to be considered, and for the valve body working below this temperature, the fitting clearance between the valve body and the valve core is based on the working conditions of its use, because of certain rules Increase. In order to ensure the normal fitting clearance of the gas valve at extremely low temperature, the working clearance and assembly clearance in the extremely low temperature environment can be calculated from Equations 1 and 2. The calculation results are shown in Table 1.

The size deviation and fit of the original XJFH-5×135 is based on a temperature of 20℃. Because the linear expansion coefficient of the bonding material is different, the fit gap (or interference) needs to be corrected and calculated to select a more correct fit. category. The calculation formula is shown in Eqs. 1 and 2 as follows:

$$x_{zmax} = x_{Gmax} + d[a_z(t_z - t) \mp a_k(t_k - t)] \quad (1)$$

$$x_{zmin} = x_{Gmin} + d[a_z(t_z - t) \mp a_k(t_k - t)] \quad (2)$$

Table 1 Air valve working clearance and assembly clearance in extremely low temperature environment

Name of valve	Part Name	Material	size	Linear expansion coefficient（$℃^{-1}$）	Working gap in extremely low temperature environment	Assembly clearance
Manual valve	Valve body	45	$\emptyset 40^{+0.025}_{0}$	11.59×10-6	max：0.034 min：0.025	max：0.034 min：0.017
	Valve core	45	$\emptyset 40^{-0.009}_{-0.025}$	11.59×10-6		
Main valve	Valve body	HT200	$\emptyset 20^{+0.021}_{0}$	9.3×10-6	max：0.054	max：0.055

	Valve core	40Cr	$\emptyset 20_{-0.033}^{-0.020}$	8.8×10-6	min：0.033	min：0.003
Air supply valve	Valve body	Q235	$\emptyset 8_{0}^{-0.036}$	10.1□×10-6	max：0.040 min：0.040	max：0.040 min：0.040
	Valve core	45	$\emptyset 8_{-0.076}^{-0.040}$	9.7×10-6		
Reversing valve	Valve body	H62	$\emptyset 51_{0}^{-0.030}$	15.2×10-6	max：-0.001 min：0.1	max：-0.029 min：-0.018
	Valve core	40Cr	$\emptyset 51_{-0.029}^{-0.010}$	8.8×10-6		
Distribution valve	Valve housing	ZQSn10-1	$\emptyset 70_{+0.010}^{+0.040}$	10×10-6	max：0.1 min：0.04	max：0.093 min：0.033
	Valve core	40Cr	$\emptyset 70_{-0.06}^{-0.03}$	8.8×10-6		
	Valve body	HT200	$\emptyset 100_{0}^{+0.035}$	9.3×10-6	max：0.01 min：-0.045	Max：0.016 min：-0.039
	Valve housing	ZQSn10-1	$\emptyset 100_{+0.025}^{+0.045}$	10×10-6		

IV. CONCLUSION

Through the calculation of the assembly gap between the valve body and the valve core at extremely low temperatures, their assembly dimensions are re-derived, and the dimensions of the valve body and the valve core of the existing pneumatic winch valve are optimized. Tests have verified that the above analysis is correct and the calculation is feasible. It fully meets the design requirements and avoids the relative rotation of the valve due to the change of the working gap in the extremely low temperature environment, resulting in dry friction between the two and damaging the airtightness of the valve body. In severe or severe cases, the valve body may jam, causing the pneumatic winch to malfunction. This method has good effects and has the advantages of economy and simplicity.

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