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Research on Pressure Independent Constant Air Volume Valve

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Abstract
In order to study the spring performance curve of the spring at the valve core of a pressure independent constant air volume valve based on the mechanical self acting principle, based on the existing research results on the characteristics of Venturi valves, this paper combines software simulation with actual experiments to obtain a set of spring performance curves using CFD simulation software, and verifies the accuracy of the software simulation data through actual experiments.
Keywords:*venturi valve;spring performance;CFD*

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I. Introduction

With the continuous development of science and technology, the quality requirements for indoor environment in fields such as scientific research and process production are increasingly high. In some special environments, in order to ensure that indoor pollutants, temperature and humidity indicators meet the corresponding requirements, it is not only necessary to strictly control the air handling process, but also to accurately control the air supply and exhaust volume of the space to ensure the stability of the pressure difference between the controlled environment and the outside world. However, in the operation process of air conditioning, the pressure difference between the air conditioning room and the outside world can be easily affected due to the increasing filter resistance, the change in the efficiency of fans and other equipment, and human operation. Therefore, how to quickly and stably control the air supply and exhaust volume of the air conditioning system and ensure that the internal and external pressure difference is not affected by various factors is one of the main problems to ensure the indoor environment quality.

In the air volume control, the valve is the main component and the core of regulating and balancing the air volume. It is very important in air volume control of the air conditioning system. It plays an indispensable role in the fresh air system, exhaust system, variable air volume system, the purification system and air duct pipeline balance.

Currently, the commonly used air volume control valves in engineering include butterfly valves, parallel multi leaf valves, split multi leaf valves, rectangular three way valves, etc. They have simple structure, low price, and convenient operation, but there are problems such as inaccurate air volume adjustment and adjustment lagging behind changes in operating conditions. On the other hand, traditional air volume control valves also have problems such as insufficient or excessive air volume regulation, resulting in ventilation not meeting environmental requirements and partial energy waste.

Due to the increasing requirements for system accuracy in air conditioning environments, constant air volume valves have come into people's sight and received great attention. The constant air volume valve does not need external power when it realizes the air volume control, but relies on the airflow force in the air duct to locate and control the position of the spool, so as to realize the output flow within the set pressure range to keep at the set value. In the current field of air conditioning, it can be roughly divided into two categories according to the controlling principle of the constant air volume valve: one is through the silicone bag in the balancer to receive the flow signal and drive the actuator to achieve the flow control; the other is to automatically locate the valve position according to the airflow pressure in the air through the self - reliant device .

We will establish a three-dimensional model for the second type of constant air volume valve for theoretical simulation, fit the spring performance curve through simulation data, and verify through experiments whether the performance of the spring meets the requirements.

II. Working principle of pressure-independent constant air volume valve

The overall structure of the pressure-independent constant air volume valve is shown in Figure 1, and its main components include the valve casing, valve core, valve stem, spring, connecting rod, and flow scale. The valve core is equipped with a spring inside. When the valve is working, the valve core is in a certain equilibrium position due to the elastic force of the spring and the airflow acting on the valve core.

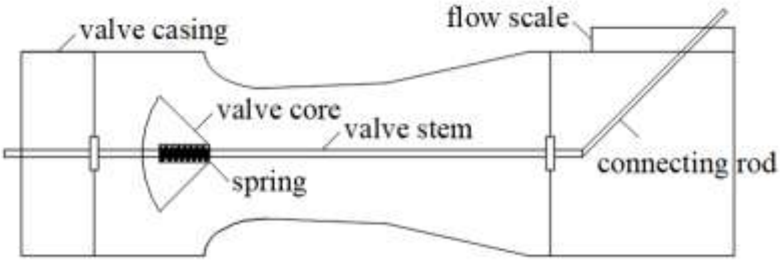

Figure 1 Overall structure of pressure-independent constant air volume valve

When the static pressure in the air duct changes, the fluid force acting on the valve core of the constant air volume valve will also change, thereby breaking the balance between the spring elastic force and the fluid force at the valve core. Under the combined action of these two aspects, the valve core undergoes displacement, thereby forming a new equilibrium and changing the flow area to ensure that the air volume remains constant.

III. CFD simulation experiment method

From the working principle of the pressure-independent constant air volume valve, it can be seen that the core part of the valve is the spring inside the valve core. In order to obtain the required spring elastic coefficient, we used SolidWorks to model the entire valve, as shown in Figure 2. Import the model into ANSYS fluent, obtain relevant experimental data through CFD simulation experiments, analyze the obtained data, and then fit the spring performance curve.

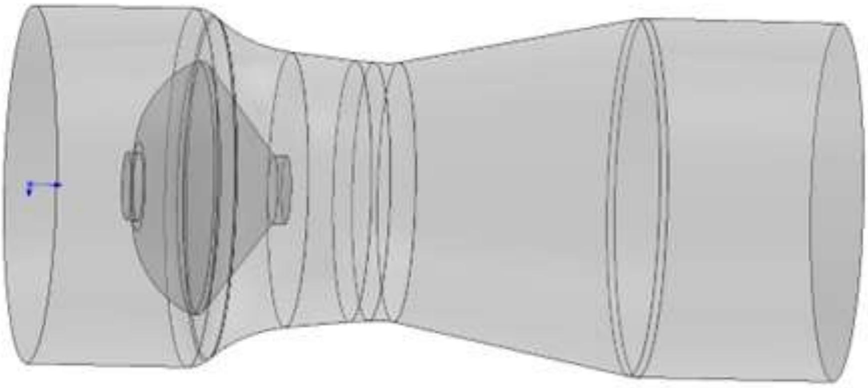

Figure 2 Model of pressure-independent constant air volume valve

First, establish a valve as shown in Figure 2 and import it into ANSYS Fluent for simulation. The initial position of the valve core is set to the center of the circular surface at the middle position of the valve body contraction section, and the x-axis negative direction is set to the centerline of the airflow direction.

Fix the valve core in the initial position and adjust the airflow from small to large, recording the magnitude of the force acting on the valve core under each working condition.

Change the position of the valve core and record the airflow, fluid action force, and other data under different working conditions.

IV. Simulation results and analysis

Based on software simulation data, the relationship curves between fluid force and flow rate at different valve core positions are obtained, as shown in Figure 3, and the relationship curves between fluid force and valve core position at different flow rates are shown in Figure 4. The relationship between the spring force of the target spring and the displacement of the valve core is obtained.

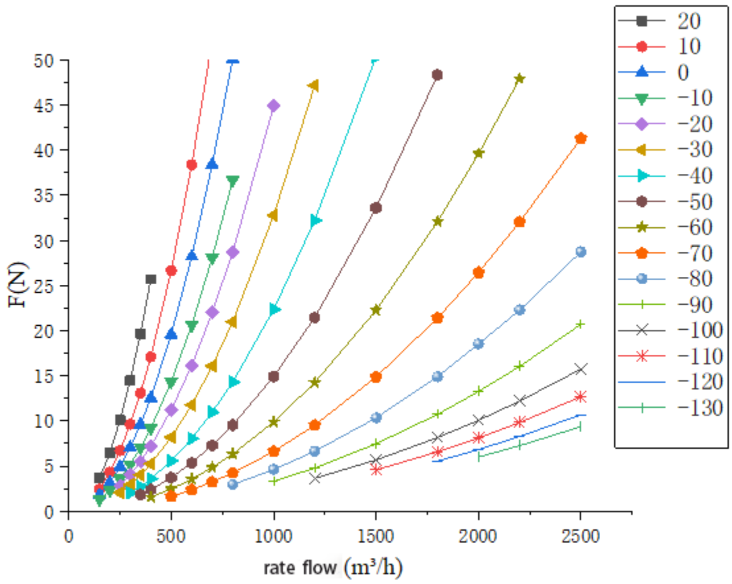

Figure 3 Relationship curve between fluid force and flow rate at different valve core positions

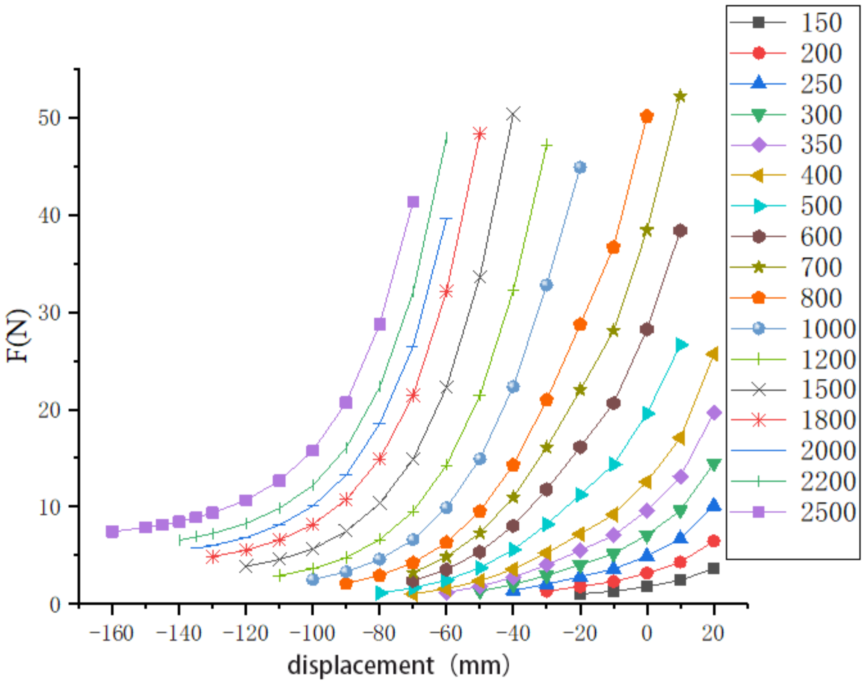

Figure 4 Relationship curve between air force and valve core position under different flow rates

As can be seen from the data in Figure 3, when the valve core position is fixed, the greater the flow rate at the valve inlet, the greater the fluid force on the valve core. From the data in Figure 4, it can be seen that the relationship curve between fluid force and valve core position is similar within a certain flow range. The spring elastic curve can be fitted according to the relationship between the air force and the position of the valve core under the corresponding working conditions.

V. Experimental verification

To verify the simulation experiment results and determine whether the springs obtained from the simulation experiment can meet the requirements of the constant air volume valve, we conducted the design of the relevant test device. The main components of the valve performance testing device include a supply fan section, an air volume measurement section, and a pressure difference measurement section. The schematic diagram of the experimental device is shown in Figure 5.

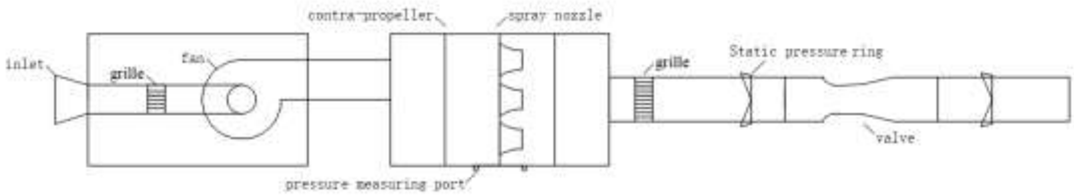

Figure 5 Schematic diagram of test device

The fan air supply section adopts a frequency conversion centrifugal fan for air supply; In order to make the inlet air flow more uniform and improve the experimental stability, a grille and air inlet pipe are installed at the inlet. The fan can provide a maximum air volume of 7000 cubic meters per hour and a maximum external residual pressure of 1500 Pa.

The air volume test section adopts throatless orifice type nozzles, equipped with five nozzles with different diameters to adjust according to working conditions. The throat diameters of the nozzles are 40mm, 50mm, 80mm, 150mm, and 189mm, with the 189mm nozzle set in the center, and the remaining four nozzles installed symmetrically relative to the air chamber axis.

Pressure measuring ports are installed at the front and rear of the nozzle, and a static pressure ring is installed at the front and rear of the measured valve body in the pressure difference measuring section. The auxiliary pipe is equipped with a rectifier to prevent swirling growth in normal axial flow. Due to the need for a sufficiently long straight pipe section before the valve body to be tested, the experimental device selects a straight pipe section with a length of 5 times the pipe diameter to be placed in front of and behind the valve body, and selects static pressure measurement points at the corresponding positions of the straight pipe section.

One side of the air chamber is connected to a forced draft fan, and the other side is connected to a test section. The air flow test range of the system is 0-7000 cubic meters per hour.

After calibrating the instrument, start the experiment. The experimental results are shown in Figure 6 below. The curves under the three working conditions can be basically consistent through translation, which is consistent with the software simulation data.

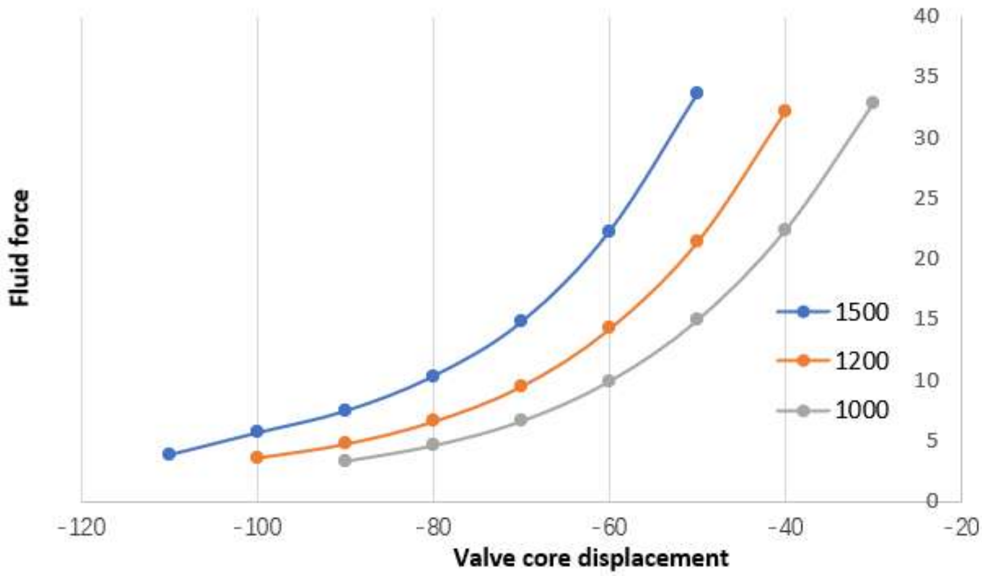

Figure 6 Spring Elastic Curve

Based on the above experimental methods, the effect of the designed valve is verified. The measured experimental data are shown in Figure 7 below. As can be seen from Figure 7, the air volume output by the valve is maintained at 1400-1650 cubic meters per hour under different valve front pressures, meeting the constant air volume requirements of the valve.

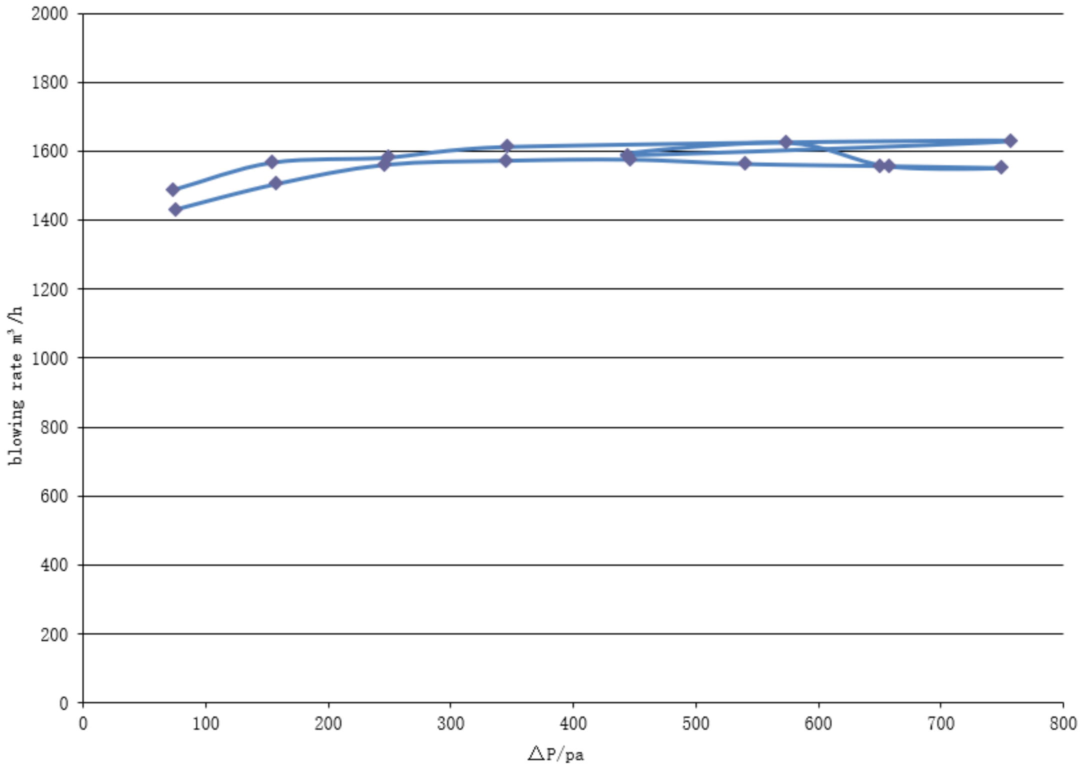

Figure 7 Validation Experiment Results

VI. CONCLUSION

In the above experiments, we found the relationship between the fluid force, flow rate, and spool displacement at the valve core of a pressure independent constant air volume valve during operation through CFD software simulation. The theoretical spring performance curve of the corresponding valve body within the air chamber pressure range of 100-750Pa was obtained and successfully verified through practical experiments.

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