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Research on static analysis of exhaust valve plate based on Ansys compressor

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Abstract: Compressor is an important equipment and main source of noise for refrigerators. Reducing the noise of refrigerators is very important for improving people's working and living environment. The energy efficiency of the compressor depends on the valve first, and the abnormal motion (flutter and closing delay) of the valve is the main cause of the extra flow loss and the main source of the source of the noise. The exhaust valve piece is prone to fatigue fracture under the applied alternating stress. In this paper, a type of tongue spring valve is selected. The static and modal analysis of the valve plate of the compressor is carried out by ANSYS software, and the natural frequency and vibration mode of the exhaust valve are obtained, which provides the theoretical basis for the optimization design of the valve plate.
Keywords: Reed valve; Alternating load; Modal analysis; fatigue fracture.

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1. INTRODUCTION

Reciprocating compressors are widely used in the field of refrigerators and refrigerators, and they are the source of noise. The aerodynamic noise is the main component of the compressor noise, and in the refrigerator compressor, the vibration of the valve piece is easily aroused by the pressure fluctuation caused by intermittent suction and exhaust. The valve plate is prone to fatigue fracture under alternate alternating stresses.

Valve disc is the main key part of reciprocating compressor. In this paper, vibration theory is used to analyze the movement of exhaust valve plate, and the mathematical model of exhaust valve piece is established, and its natural frequency is analyzed. By using the Fluent simulation software to simulate the piston motion, the alternating load on the exhaust valve plate is obtained, and the modal analysis of the exhaust valve is carried out with the ANSYS simulation, and the natural frequency and vibration mode of the exhaust valve are obtained.

2. VIBRATION THEORY AND MATHEMATICAL MODEL OF EXHAUST VALVE

2.1 Vibration theory of exhaust valve

For the simulation of the working process of the exhaust valve, it is assumed that the piston cylinder is a thermodynamic system, and the influence of the viscous damping force of the refrigerant is not considered.

With the rotation of the crankshaft, the reciprocating movement of the piston, the periodic completion and closing of the exhaust valve, for the current scheme of the existing exhaust valve structure, the venting valve plates easily cause the trembling of the valve plates and the delay of closing the two abnormal movements. The so-called delay closing refers to the impact of the valve plate on the lift limiter after the valve is opened. After a slight reverse jump, it is reattached to the lift limiter until the valve plate begins to close. And its own stiffness is small, leading to the closure of the valve plate long and slow down, so that the valve is not closed until the piston reaches the stop point until the piston moves for a period of time before falling to the seat.

2.2 Mathematical model of exhaust valve plate

In the working process of the reed exhaust valve, the cantilever beam model regards the exhaust valve of the equal width strip reed valve as the cantilever beam, one end clamps, and the other side is free. The following figure is shown in Fig. 1

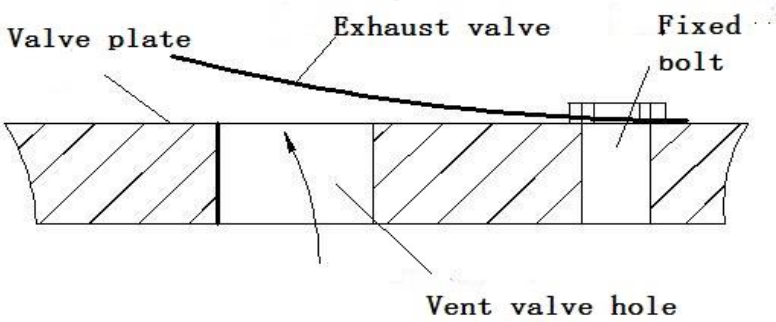

Fig. 1 Working principle diagram of exhaust valve

2.3 Motion equation of valve plate

The motion of valve plate can be regarded as the motion differential equation of valve disc subjected to uniform load under the push of airflow.

$$\frac{\partial^4 y}{\partial x^4}+\frac{1}{a^2}\frac{\partial^2 y}{\partial t^2}=\frac{q}{EJ}$$

In the formula E —Elastic modulus of valve material, N/m^2;

J- Section inertia moment of valve section, m^4

ρ- Material density of valve plate, kg/m^3;

A_c-Cross section of valve platem^2

The parameter$a$ is composed of E, J ,ρ, A_c,

$$a=\sqrt{\frac{EJ}{\rho A_C}}$$

From the differential equation of valve plate, we can see that the motion of valve plate is composed of free vibration and forced vibration.

The solution of the equation has the following form,

$$y = \sum_{i=1}^{\infty} \emptyset_i X_i$$

In the formula, $\emptyset_i$ is the time function of forced vibration, and X_i is the time function of free vibration. When $x = L_1$ Motion differential equation at the end of the valve plate

$$\frac{d^2y}{\partial t^2} + \frac{a^2(k_1L_1)^4}{{L_1}^4} y = \frac{1.566}{A_c\rho} q$$

Among $q = \beta b(p - p_d)$

q is the unit length of the gas thrust N/m

β Thrust coefficient

b Valve width m

p_b Gas pressure in the exhaust chamber N/m^2;

p Gas pressure in cylinder N/m^2;

The Y is the displacement of the end of the valve.

2.4 Model establishment and grid partition

Building model in 3D drawing software,Importing the workbench into grid partition,As shown in Fig.2 below

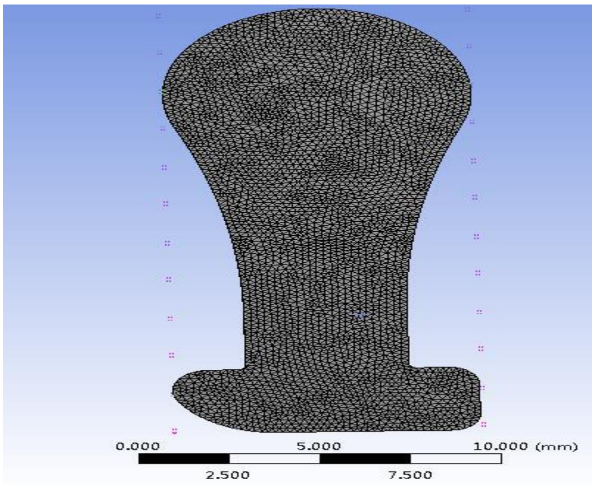

Fig.2 Grid partition

3. CALCULATION OF THE FORCE OF THE ALTERNATING LOAD ON THE EXHAUST VALVE

One end of the exhaust valve is fixed, and the calculation results of the above piston cylinder are acted on the exhaust valve sheet for finite element analysis. In order to reduce the impact of the valve on the lift limiter, the maximum stress is compared with the allowable bending stress of the material by calculating the maximum pressure. The simulation results show that the maximum stress appears at the end of the valve plate. Therefore, the impact of the valve plate on the lift limiter should be optimized when the valve plate is optimized in the future, thus reducing the noise.

4. MODAL ANALY OF EXHAUST VALVE

4.1 Support of kinetic theory

General equation of dynamics

$$[M]\{\ddot{u}\} + [C]\{\dot{u}\} + [K]\{u\} = \{F(t)\}$$

Among

$[M]$ mass matrix

$[C]$ Damping matrix

$[K]$ Stiffness matrix

$\{\dot{u}\}$ speed

$\{\ddot{u}\}$ acceleration

$\{u\}$ Displacement matrix

$\{F(t)\}$ Force,Modal analysis. $\{F(t)\} = 0$.

For exhaust valve plate, the model can be simplified, and the damping of valve plate is ignored. The material is linear elastic body.

$\{F(t)\} = 0$,Free vibration.

The model and calculation of the exhaust valve sheet can be simplified as follows.

material is linear elastomer;

for the metal material, the valve is ignored as damping, and the vibration is regarded as free vibration. Through the comparison and analysis of the five order modal cloud images of the exhaust valve, the exhaust valve plate is shown from the first to the three order natural frequency. In the optimization design of other structures, t path or structural parameters should be changed to avoid the resonant frequencies of the components effectively.

Through the comparison and analysis of the three order modes of the exhaust valve, the natural frequencies of the valve pieces from the first to the six order are 650.83Hz, 4133Hz and 5104.06Hz respectively, so the resonance should be avoided when the other valve plate components are designed.

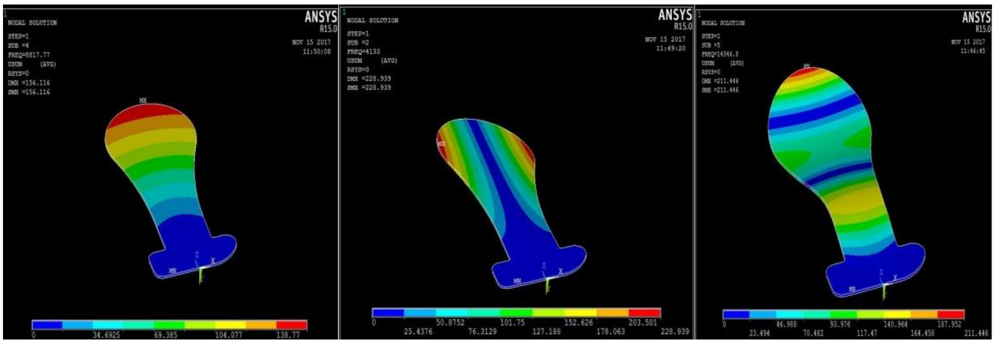

Fig.3 Modal shape diagram of exhaust valve

5. SUMMARY

Through the Ansys modal analysis, the three order resonance frequency of the exhaust valve and the vibration modes of each order are obtained, and the bending stress of the vent valve is maximum. Therefore, at the most dangerous breaking point, whether the valve plate is qualified and whether it has reached the allowable strength of the material, the valve piece can be effectively reduced by the optimum design of the valve plate. The maximum bending stress increases the bending fatigue resistance of the valve plate. In order to prepare for the optimum design of the thickness of the valve plate in the future.

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