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Volume Change and Area of Exhaust Hole Change of Double Profiles Scroll Compressor

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Abstract

The profile equation of the double scroll profile scroll compressor is given, and the geometric model of the double scroll profile scroll compressor is established. The volume calculation formula is derived, the volume change curve is drawn, and the volume change of the double scroll profile scroll compressor is analyzed. The change of exhaust area with the spindle angle is analyzed, which provides a reference for the research of double scroll profile scroll compressor.

Keywords

Double scroll profile; Scroll compressor; Volume change; Exhaust hole.

1. Introduction

Scroll compressor is a new type of energy conversion device which can realize gas expansion by means of volume change. It has the advantages of simple structure, few parts and light weight. At present, it is widely used in refrigeration equipment, low-grade waste heat recovery and other fields [1]. Because of its low pressure ratio, large displacement and low friction speed of sliding surface. Double vortex scroll compressor is widely used in high power applications [2]. Reference [3] introduced the types and characteristics of common profiles, modified profiles and combined profiles of scroll compressors, as well as the selection and evaluation criteria of profiles. Reference [4] studied the influence of discharge hole area on the performance and efficiency of single scroll compressor, and derived the boundary equation of the opening area of exhaust hole theory in detail. Reference [5] analyzed the existing problems in the design of single scroll compressor with large discharge capacity. In reference [6], the leakage characteristics of oil-free single scroll compressor were studied, and the results show that the leakage has the greatest impact on the mass. The mathematical model of the scroll compressor considering heat transfer and leakage was established in reference [7]. Through solving the model, the volume change curve and P-V diagram of the working chamber of the scroll compressor were obtained, and the variation law of the leakage mass flow and the total mass flow with the spindle angle were obtained. The experimental platform was built to compare the measured experimental data with the theoretical value, It is concluded that the established model can accurately reflect the actual compression process of the compressor; the dynamic characteristics of the double scroll profile scroll compressor are analyzed in reference [8-11].

When the scroll compressor is used in internal combustion engine, gas engine, supercharger and other fields, it is necessary to ensure the compression ratio and increase the displacement at the same time. If the single scroll profile scroll compressor is used, the size of the dynamic and static scroll plates and the whole machine will increase greatly, and the rotating radius of the moving scroll will increase, and the eccentric moment caused by it will increase. However, the above problems can be solved by using the double scroll profile scroll compressor. Therefore, it is necessary to study the double vortex scroll compressor [12]. In this paper, the geometric model of the scroll compressor with double vortices is established, the volume calculation formula is derived, and the volume variation law is

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analyzed. The research on the change of the exhaust hole area with the spindle angle is of certain significance to the study of the double vortex coil in the future.

2. Geometric model of double scroll profiles scroll compressor

2.1 baseline equation and inner and outer wall equation

The baseline equation of double scroll profiles scroll compressor is as follows:

$$\begin{cases} x = r_b \cos\varphi + r_b\varphi\sin\varphi \\ y = r_b \sin\varphi - r_b\varphi\cos\varphi \end{cases} \tag{1}$$

Where, r_b is the radius of the base circle and φ is the involute angle.

Outer wall equation of double scroll profile scroll compressor is as follows:

$$\begin{cases} x_{1i} = r_b[\cos(\varphi-\alpha)+\varphi\sin(\varphi-\alpha)] \\ y_{1i} = r_b[\sin(\varphi-\alpha)-\varphi\cos(\varphi-\alpha)] \\ x_{2i} = r_b[\cos(\varphi+\alpha-\pi)+\varphi\sin(\varphi+\alpha-\pi)] \\ y_{2i} = r_b[\sin(\varphi+\alpha-\pi)-\varphi\cos(\varphi+\alpha-\pi)] \end{cases} \tag{2}$$

Where, α is the angle of involute.

Inner wall equation of double scroll profile scroll compressor is as follows:

$$\begin{cases} x_{1o} = r_b[\cos(\varphi+\alpha)+\varphi\sin(\varphi+\alpha)] \\ y_{1o} = r_b[\sin(\varphi+\alpha)-\varphi\cos(\varphi+\alpha)] \\ x_{2o} = r_b[\cos(\varphi+\alpha+\pi)+\varphi\sin(\varphi+\alpha+\pi)] \\ y_{2o} = r_b[\sin(\varphi+\alpha+\pi)-\varphi\cos(\varphi+\alpha+\pi)] \end{cases} \tag{3}$$

According to the above formula, the double vortex ring vortex tooth is shown in Figure 1, and the correct installation position is shown in Figure 2.

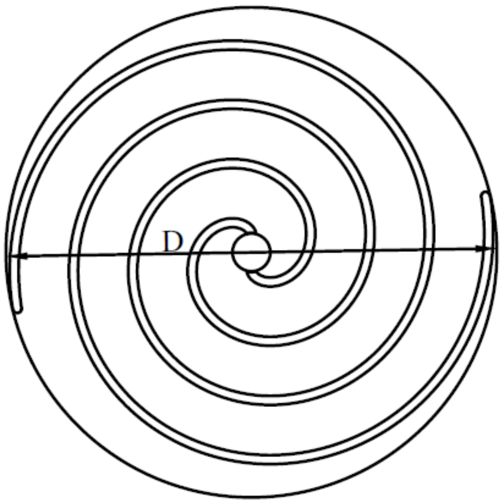

Figure 1. Schematic diagram of double scroll profile

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Figure 2. Schematic diagram of correct installation

2.2 volume calculation formula

When the working chamber is in the intake state, the projection area formula of the working chamber is as follows:

$$S=\frac{1}{8}r_b\theta(4\phi_e-2\theta-\pi)(P_t-2t) \tag{4}$$

Where, θ is the spindle angle, ϕ_e is the centre line development angle, P_t is the pitch, t is the wall thickness.

The calculation formula of intake chamber volume is as follows:

$$V_s=4H\left\{\begin{array}{l}\int_{\phi_e-\alpha-2\pi}^{\phi_e-\alpha}\frac{1}{2}(r_b\phi)^2d\phi \\ -\int_{\phi_e+\alpha-\frac{5}{2}\pi}^{\phi+\alpha-\frac{1}{2}\pi}\frac{1}{2}(r_b\phi)^2d\phi\end{array}\right\}=HP_t\left(P_t\text{-}2t\right)\left(4\phi_e-5\pi\right) \tag{5}$$

Calculation formula for volume of compression chamber is as follows:

$$V_i=\begin{cases}\frac{1}{8}Hr_b(\theta+\frac{i-1}{2}\pi)[4\phi_e-2\theta-i\pi](P_t-2t) & 0\le\theta\le2\pi-\frac{i-1}{2}\pi \\ HP_t(P_t-2t)(\phi_e-\theta-\frac{2i-5}{4}\pi) & 2\pi-\frac{i-1}{2}\pi\le\theta_i\le\theta-\frac{i-1}{2}\pi\end{cases} \tag{6}$$

Where, H is the tooth height and i is the serial number of the compression chamber.

Calculation formula of exhaust chamber volume is as follows:

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$$V_d = 4H\left\{\begin{array}{l}\displaystyle\int_{\phi_s-\alpha+\frac{\pi}{2}}^{\phi_s-\alpha+\frac{\pi}{2}+2\pi}\frac{1}{2}(r_b\phi)^2 d\phi \\ \displaystyle-\int_{\phi_s+\alpha}^{\phi_s+\alpha+2\pi}\frac{1}{2}(r_b\phi)^2 d\phi\end{array}\right\} = HP_t\left(P_t\text{-}2t\right)\left(4\phi_s+5\pi\right) \quad (7)$$

Where, ϕ_s is the terminal involute angle.

2.3 Volume change curve

The change of intake chamber volume with spindle angle is shown in Figure 3.

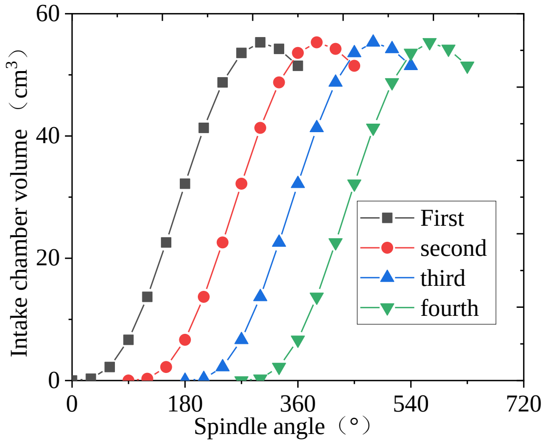

Figure 3. Change of suction chamber volume

It can be seen from Fig. 3 that the four intake chambers start to inhale every 90° and start to inhale when the spindle angle turns to 0°, 90°, 180° and 270° respectively. The rotation angle of the main shaft should be turned 360° for each intake chamber to complete the intake process, and 630° for the four suction chambers to complete the suction process. The volume curves of the four intake chambers were similar, but the beginning and ending positions were different.

The change of the volume of the compression chamber with the spindle angle is shown in Figure 4.

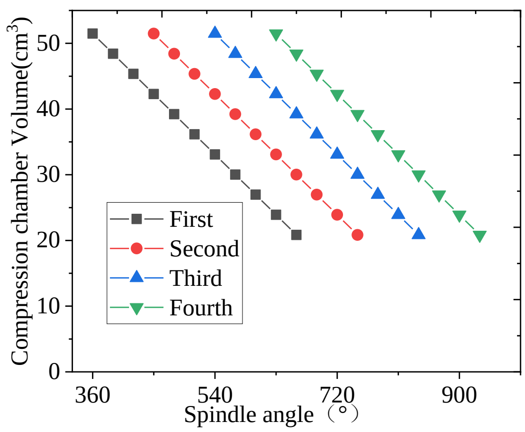

Figure 4. Volume change of compression chamber

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It can be seen from Fig. 4 that the four compression cavities start to compress every 90° and start to compress when the spindle angle turns to 360°, 450°, 540° and 630° respectively. Each compression chamber needs to rotate the spindle angle 265.9° to complete the compression process, and 535.9° is required for the four compression chambers to complete the suction process. The volume curves of the four compression chambers are similar, only the beginning and ending positions are different.

3. Effect of exhaust hole on Performance

The exhaust hole studied in paper is located at the centre of the static scroll. With the change of spindle angle, the moving scroll will block the exhaust hole periodically, which will lead to the change of exhaust hole area and the change of exhaust process. The exhaust hole area diagram is shown in Figure 5.

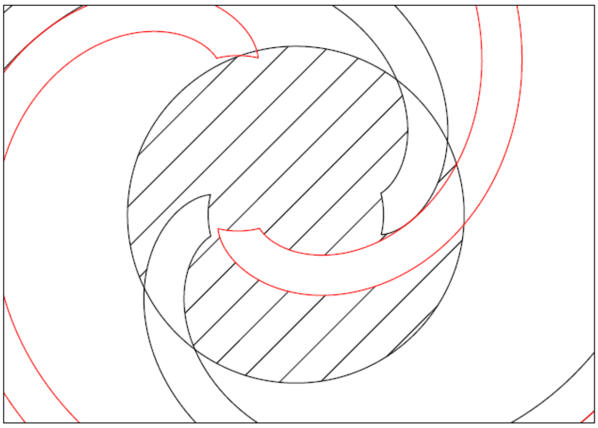

Figure 5. Schematic diagram of exhaust area

The change trend of exhaust hole area with spindle angle is shown in Figure 6.

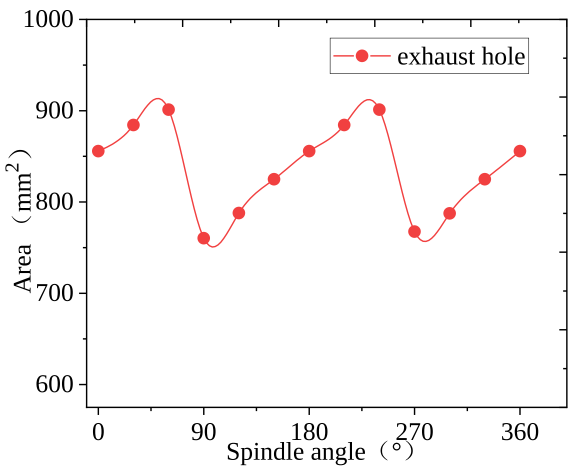

Figure 6. Variation of exhaust area

It can be seen from Figure 6 that the exhaust hole area of the double scroll profile scroll compressor changes periodically with 180° and the difference between the maximum value and the minimum value is 128.6518mm^2, and the percentage is 13.94%. The difference between the maximum value and the minimum value of single scroll compressor is about 46.53%. Therefore, the discharge hole area fluctuation of the double scroll profile scroll compressor is small, which indicates that the stability of the exhaust process is good.

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4. Conclusion

1. The geometric model of the double scroll profile scroll compressor is established, the volume calculation formula is derived, the volume change curve is drawn, and the volume change of the double scroll profile scroll compressor is analyzed. The four working chambers began to inhale and compress every 90 degrees, and their volume change curves were similar, only the starting and ending positions were different.

2. The area of the exhaust hole in the centre of the base circle of the scroll compressor is analyzed. The area of the exhaust hole of the double scroll profile scroll compressor changes periodically with 180° and the difference between the maximum value and the minimum value is 128.6518 mm^2, and the percentage is 13.94%. The fluctuation is small, which indicates that the exhaust process has good stability.

Acknowledgments

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