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THE STUDY OF CHARACTERISTICS WITH SMALLER OVERTURNING MOMENT FOR SCROLL COMPRESSOR

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ABSTRACT

According to the structure features that the scroll wrap is cut and the area without scroll wrap is increased in the central portion of orbiting and fixed scroll for larger displacement volume and lower pressure ratio scroll compressor, the driving bearing can be now fixed into the scroll wrap. As a result of our comprehensive analyses to inertia force and inertia moment acting on the crankshaft as well as different kinds of forces acting on the orbiting scroll, it is concluded that the overturning moment acting on the driving bearing, which results from either gas force or inertia force of orbiting scroll, is reduced, and the working stability of the scroll compressor is increased. This paper puts forward a set of formulas, which are derived based on some geometric parameters of larger displacement volume and lower pressure ratio scroll compressor. The formulas can be used to determine the suction volume, discharge volume, build-in volume ratio, scroll wrap starting angle, suction commence angle and discharging commence angle.

1. INTRODUCTION

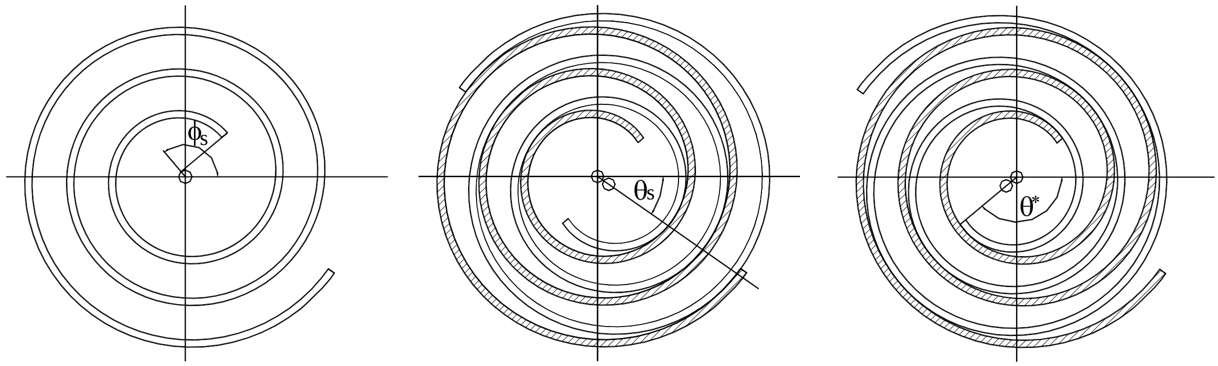
With the development of modern manufacture techniques and computer technology, the application fields of scroll fluid machine have been widened gradually. Since the scroll compressor is used for air conditioners in 80's, now the application of scroll compressors has be extended to more engineering fields, such as air scroll compressor , scroll expansion machine，scroll vacuum pump, scroll liquid pump, and scroll engine as well.[1][2][3][4] By surveying a large quantity of published papers we found that there are only a few of papers concerning larger displacement volume and lower pressure ratio scroll compressor. In this paper, some geometric parameters of orbiting and fixed scroll are analyzed, and the calculation formulae of geometric parameters are given for larger displacement volume and lower pressure ratio scroll compressor. In virtue of the driving bearing is set into the scroll wrap, the smaller overturning moment acting on orbiting scroll is realized. The forces acting on orbiting scroll and the inertia force acting on the crankshaft are analyzed.

2. GEOMETRIC THEORY

It is necessary that the scroll wrap of orbiting and fixed scroll in central area be cut for larger displacement volume and lower pressure ratio scroll compressor, as shown in figure 1. By means of the two special parameters, which are the final angle, ϕ_e, and the starting angle, ϕ_s, for midline of scroll wrap thickness, we can simplify calculate the suction volume and the discharge volume after the central portion of scroll wrap is cut.

The area of involute of a circle can be calculated by, [5]

$$s = \int_0^{\phi} \frac{1}{2} a^2 \phi^2 d\phi \tag{1}$$



(a) scroll wrap starting angle (b) suction commence angle (c) discharging commence angle

Figure 1: starting angle, suction commence angle and discharging commence angle

So the suction volume, V_s, is obtained by,

$$V_s = 2sh = 2h\left(\int_{\phi_e-2\pi-\alpha}^{\phi_e-\alpha} \frac{a^2}{2}\phi^2 d\phi - \int_{\phi_e-3\pi+\alpha}^{\phi_e-\pi+\alpha} \frac{a^2}{2}\phi^2 d\phi\right) = Ph\left(\frac{P}{2}-t\right)(2\phi_e - 3\pi) \tag{2}$$

Where, P is scroll wrap pitch, h is scroll wrap height, t is scroll wrap thickness, ϕ_e is the final angle for midline of scroll wrap thickness.

The discharge volume, V_c, is given by,

$$V_c = 2sh = 2h\left(\int_{\phi_s+\pi-\alpha}^{\phi_s+3\pi-\alpha} \frac{a^2}{2}\phi^2 d\phi - \int_{\phi_s+\alpha}^{\phi_s+2\pi+\alpha} \frac{a^2}{2}\phi^2 d\phi\right) = Ph\left(\frac{P}{2}-t\right)(2\phi_s + 3\pi) \tag{3}$$

Where, ϕ_s is the starting angle for midline of scroll wrap thickness.

Therefore, the build-in volume ratio, v, can be expressed by,

$$v = \frac{V_s}{V_c} = \frac{2\phi_e - 3\pi}{2\phi_s + 3\pi} \tag{4}$$

The starting angle, ϕ_s, for midline of scroll wrap thickness is given by,

$$\phi_s = \frac{2\phi_e - 3\pi}{2\varepsilon^{\frac{1}{m}}} - \frac{3}{2}\pi \tag{5}$$

Where, ε is pressure ratio, m is polytropic exponent.

The suction commence angle, θ_s , is expressed by,

$$\theta_s = 2\pi\{1 - [n - \mathrm{int}(n)]\} \tag{6}$$

The discharging commence angle, θ^*, can be calculated by,

$$\theta = \frac{7}{2}\pi - \phi_s \tag{7}$$

$$\begin{cases} \theta^* = \theta - 2\pi & (\theta \geq 2\pi) \\ \theta^* = \theta & (\theta \langle 2\pi) \end{cases} \tag{8}$$

3.INERTIA FORCE AND INERTIA MOMENT

When the rotor of scroll compressor performs the rotary motion, the eccentric mass would result in centrifugal force. The centrifugal force F_c produced by orbiting scroll acts on the center of mass itself, and inertia force F_p of crank pin acts on the midpoint of crank pin length (that is within driving plane of orbiting scroll). The inertia forces of the main and vice balance iron act respectively on the position between orbiting scroll and main bearing as well as on the strap wheel, as shown in figure 2. From force and the moment balance for the main bearing A-A plane, the equation (9) is obtained.

$$\begin{aligned} F_c + F_p + F_{b2} &= F_{b1} \\ F_c h_c + F_p h_p &= F_{b1} h_{b1} + F_{b2} h_{b2} \end{aligned} \tag{9}$$

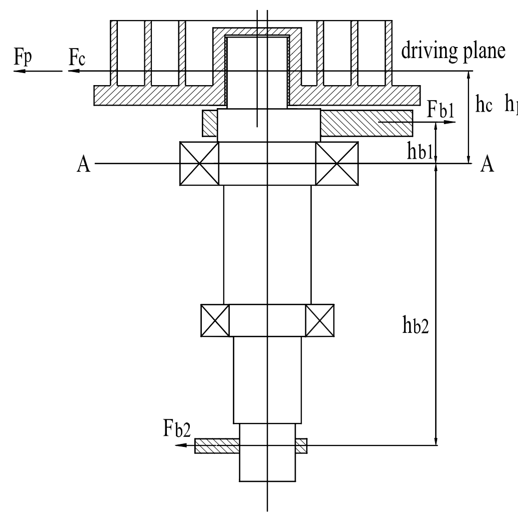


Figure 2: inertia force and inertia moment

Owing to driving bearing is set into the orbiting scroll, we can overlap the driving plane and the centroid plane of orbiting scroll. The distance from the plane of center of mass of orbiting scroll to main bearing plane is decreased. It is known from equation (9) that the moment acting on main bearing A-A plane, which is generated by centrifugal force of the orbiting scroll, is reduced, meanwhile the weight of the main and vice balance iron is also reduced. As a result, the weight of rotor can be decreased. Furthermore, the moment which acts on the driving plane of orbiting scroll by inertia force of orbiting scroll is equal to zero, which the working situation of driving bearing is improved, and the using lifespan of driving bearing is prolonged, and a smooth operation and lower frictional work consumption for scroll compressor are realized.

4. FORCES ON THE ORBITING SCROLL

The forces acting on the orbiting scroll include: gas force, inertia force, and frictional force and so on. These forces are given in figure 3. When driving bearing is embedded into scroll wrap, the distance from driving plane to the plane of the radial force F_r and the tangential force F_t on the orbiting scroll is reduced. Consequently, the overturning moment that acts on orbiting scroll is lessened, which is generated by the radial force F_r and the tangential force F_t .

5.CONCLUSION

(1) The driving bearing of orbiting scroll is embedded into orbiting scroll wrap, and the overturning moment, which acts on orbiting scroll created by the radial force F_r and the tangential force F_t , is lessened. Besides, it is equal to zero that the overturning moment acts on the orbiting scroll by centrifugal force of orbiting scroll, and the

working stability of the scroll compressor is enhanced.
(2) The plane of Inertia force function for orbiting scroll overlaps with the driving plane of orbiting scroll, which the moment that acts on main bearing by the inertia force of orbiting scroll is reduced, and the working situation of crankshaft and main bearing is improved.
(3) The forces situation is improved for driving bearing and the using lifespan of driving bearing is prolonged.

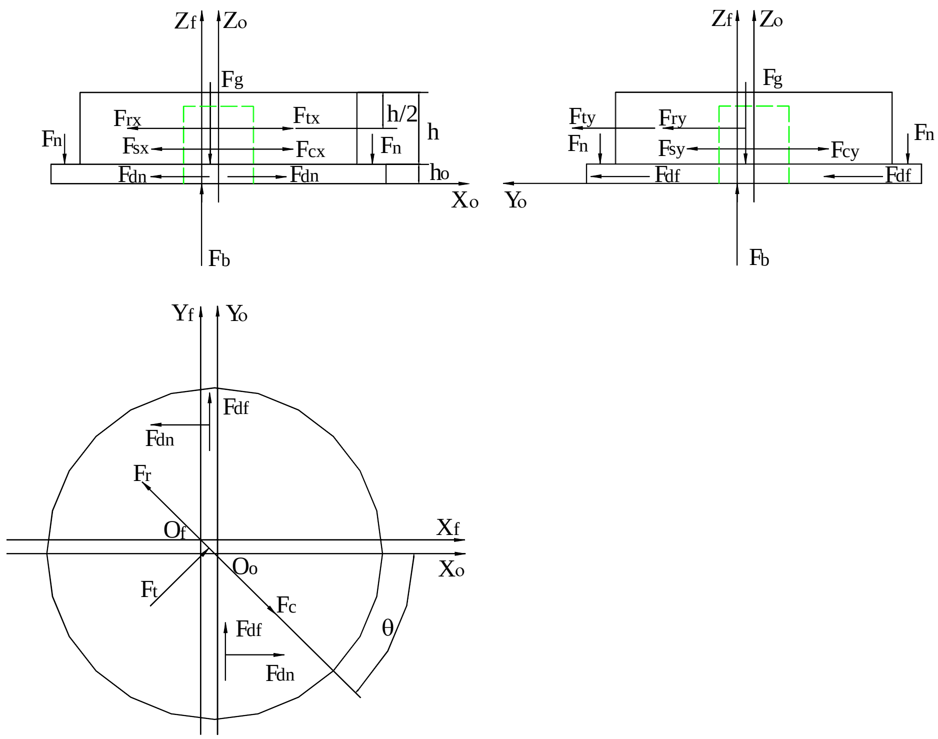


Figure 3: forces on the orbiting scroll

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