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Discussion on leaking characters in meso-scroll compressor

*Chen Rong, Wang Wen**

Institute of Refrigeration & Cryogenics, Shanghai Jiao Tong University, 800 Dongchuan Road, Shanghai 200240, China

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ABSTRACT

The leakage is unavoidable and has considerable influence on the performance of a scroll compressor. In a meso-scale scroll compressor, the working gas leakage is more serious because the gaps between the scroll plate pairs are more difficult to be sealed than the case in a normal scale scroll compressor. This paper analyzes the leakage and related factors with a simplified model, and discusses the performance that resulted from gas loss due to both leakages from tangential and axial directions in meso-scale compressors. The discussion and related results are helpful to determine some key parameters in the design and manufacture of meso-scroll compressors.

Compresseur à mésospirale : discussion sur les caractéristiques des fuites

Mots clés : Compresseur à spirale ; Géométrie ; Enquête ; Paramétre ; Fuite

1. Introduction

In general, a common vapor compression air-conditioning system serves for cooling capacity of more than 200 W at present. However, with the requirement from personal cooling and thermal control for electronic components, small scale cooling technology with the cooling capacity of less than 100 W, even less than 5 W cooling capacity, collected many attentions, so the meso- or micro-scale cooling systems are demanded. One of the key technologies for the solutions is developing the meso- or micro-scale compressor.

The scroll compressor has now been widely used to vapor compression refrigerant and heat pump with some advantages, such as high efficiency, low vibration, and compact structure, so it is a good candidate to be developed and miniaturized to serve for a meso-cooling system.

If a meso-scroll compressor (MSC) were designed for a compression refrigeration system with 30 W cooling capacity for air-conditioning, the size of its scroll plates would be similar as a cent coin, as shown in Fig. 1. Theoretically, whatever size it is, the scroll plate could be designed by miniaturizing from normal scale scroll plate without the confinement from

* *Corresponding author*. Tel./fax: +86 21 62932601.
E-mail address: wenwang@sjtu.edu.cn (W. Wen).

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Nomenclature

C_1, C_2	constants
COP	coefficient of performance
c_p	specific heat capacity of leaking gas (J kg^{-1} K^{-1})
D	equivalent diameter of the cross-section (m)
H	height of scroll wall (m)
h	enthalpy of leaking gas (kJ kg^{-1})
L	length (m)
M	mass (kg)
p	static pressure of leaking gas (Pa)
Q	mass flow rate of leaking gas (kg s^{-1})
R	gas constant
r	radius of basic circle (m)
s	arc-length of involutes (m)
T	absolute temperature of leaking gas (K)
t	time (s)
u	velocity of leaking gas (m s^{-1})
W	thickness of the scroll wall (m)

Greek letters

δ	clearance (m)
γ	ratio of specific heats
η	leakage ratio (kg kg^{-1})
λ	coefficient of flow resistance
$\bar{\lambda}$	average coefficient of flow resistance
θ	orbiting angle (rad)
ρ	mass density of leaking gas (kg m^{-3})
σ	height of tangential leakage path (m)
ξ	constant

Subscripts

A	axial
abt	tangential leakage from chamber A to chamber B
abr	radial leakage from chamber A to chamber B
B	chamber B
bct	tangential leakage from chamber B to chamber C
bcr	radial leakage from chamber B to chamber C
i	inner
L	leakage
o	outer
R	radial
S	suction
T	tangential

fabrication. By now, with the development of MEMS and micro-machining technologies, it is possible to produce such meso-scroll groove profile with high precise already. However, as a scroll disk for compressor, all the surfaces of the scroll profile are touching and sealing surfaces, that is, the surface clearance is also very important besides the profile requirement.

In fact, the manufacture of meso-scroll compressor would face great challenges by now. Although the meso-scroll grooves could be made with the developing micro-machining manufacture technologies, some surfaces are still hard to be polished at present. In commercial scroll compressors, there usually are sealing tips on the roof of scroll walls as a special sealing structure to prevent working gas from leaking in radial direction, and there is retuse ditch on the top of scroll wall for fixing the strip. In a meso-scroll plate, usually there is not enough space for machining the ditch and fixing the strip on the scroll wall. Without special sealing structure, the profile and surface precise in manufacture should be controlled more carefully and accurately.

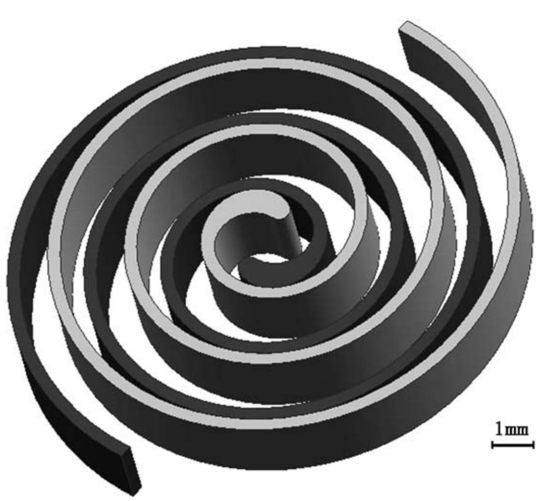

Fig. 1 – Scroll walls of an MSC with PMP profiles modelled by computer.

It is well known that the leakage in scroll compressor is quite sensitive to the gap clearance between the orbiting scroll plate and the fixed one. Unfortunately, the gap always and unavoidably exists in actual operation. In order to confine the leakage impact in a reasonable range in design, the tolerances in the scroll disks fabrication should be controlled at first, which are determined by the fabrication technology and related cost, as well as various strains in operation.

In general, the leakage occurs through the narrow paths between a high-pressure chamber and its adjoining low-pressure chamber in a scroll compressor, which can be divided into two kinds, the tangential leakage and the radial leakage. Fig. 2 presents the tangential leakage, which occurs through the narrow gap between the side faces of the orbiting scroll and the fixed one. The radial leakage, presented in Fig. 3, occurs between the tip of scroll wall and the groove bottom of the opposite scroll plate.

Some studies on the leakage and involved characteristics in scroll compressors had been carried out in previous literatures,

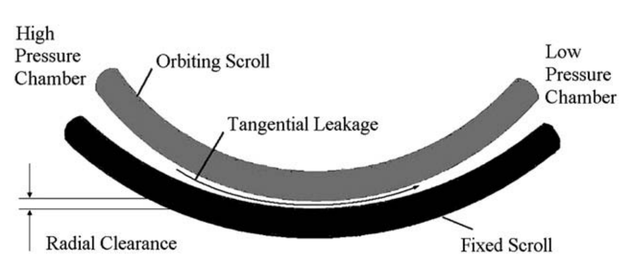

Fig. 2 – Tangential leakage path in scroll compressor.