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# DEVELOPMENT OF THE HYBRID SCROLL COMPRESSORS

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## ABSTRACT

We have developed the hybrid type scroll compressor operable the motor chamber also by discharge gas or suction gas because of taking advantage of both features. The developed compressor attains shortening the startup duration of heating system since hot gas is directly discharged from the start, using the motor chamber as the suction gas in heating mode. Moreover, the compressor attains high COP using the motor chamber as the discharge gas in cooling mode since suction gas heating is small.

The developed compressor has achieved the compressor COP more than usual in cooling mode and has made the startup duration of heating system half than usual in heating mode.

## INTRODUCTION

The two types of gas distribution systems, high-pressure design and low-pressure design, are used in hermetic type scroll compressors. The former that makes the motor chamber discharge pressure has the following features; high efficiency due to minimal suction gas heating. On the other hand, the latter that makes the motor chamber suction pressure also has the following features; shortening the startup duration of heating system since hot gas is directly discharged from the start. While the improvement in efficiency of an air-conditioner is required from an energy-conservation problem in recent years, the demand for shortening the startup duration of heating system from comparison with other heating instruments is increasing.

Consequently, we have developed the hybrid type scroll compressors operable in both high-pressure design and low-pressure design because of taking advantage of both features.

## THE FEATURE OF A NEW MECHANISM

### Pressure Changing System

The pressure change in the motor chamber is possible by using the 4-way valve currently used for the heat pump air-conditioners.

Fig.1 shows a refrigerant circuit using a hybrid type scroll compressor. The interior of the housing is divided into three chambers. These are a refrigerant compressing chamber, a refrigerant discharge chamber and a motor chamber. The discharge pipe is connected to the discharge chamber. The suction pipe is directly connected to a suction port of the refrigerant compressing chamber. The discharge pipe and the suction pipe are connected to the 4-way valve, respectively. Two connecting pipes, one pipe is connected to the 4-way valve and another is connected to the outside heat exchanger, are both connected to the motor chamber. From this, the motor chamber is at discharge pressure in cooling mode and is at suction pressure in heating mode by using the 4-way valve.

The Refrigerant Flow In The Heating Operation Mode

Fig. 1 (a) shows the refrigerant flow in heating mode. The 4-way valve is switched as shown in Fig. 1 (a). Thereupon, the high-pressure refrigerant gas produced in the refrigerant compressing chamber is supplied from the refrigerant discharge chamber to the inside heat exchanger through the discharge pipe, 4-way valve, by which heating of the room is performed. The low-pressure refrigerant gas passing through the expansion valve and the outside heat exchanger flows into the motor chamber, and is returned to the refrigerant compressing chamber through the 4-way valve.

Thus, the compressor can be made the low-pressure type in heating mode.

The Refrigerant Flow In The Cooling Operation Mode

Fig. 1 (b) shows the refrigerant flow in cooling mode. The 4-way valve is switched as shown in Fig. 1 (b). Thereupon, the high-pressure refrigerant gas produced in the refrigerant compressing chamber flows into the motor chamber from the refrigerant discharge chamber through the discharge pipe, 4-way valve, and is supplied to the outside heat exchanger through the pipe, which is connected to the motor chamber. The low-pressure refrigerant gas is returned to the refrigerant compressing chamber through the 4-way valve, the suction pipe.

Thus, the compressor can be made the high-pressure type in cooling mode.

## Optimization Of Axial Force

Generally, in scroll compressor, it is required to push the orbiting scroll in the direction of an axis by the optimal force to the fixed scroll in order to form a compression chamber. If the axial force is too small, two scrolls will be pushed apart, the leak of the gas in a compression chamber will arise, and the efficiency will be lost. Conversely, if the axial force is too large, the friction loss will increase and the efficiency will be lost.

The point of our development in the hybrid type scroll compressor, which changes the pressure in the motor chamber, is a new structure, which optimizes this axial force in both operation modes, since this axial force depends on the pressure in the motor chamber.

Fig. 2 shows the optimization of the axial force by the original thrust-ring. The backside space of the thrust-ring, which is separated by two seal rings, is designed by being made the pressure contrary to the pressure in the motor chamber. That is, when the motor chamber is at discharge pressure, the backside space of the thrust-ring is made suction pressure, and the motor chamber is at suction pressure, the backside space of the thrust-ring is made discharge pressure. By this mechanism, the axial force can be made almost equal in both operation modes. Thus, the optimization of the axial force is possible in both operation modes.

Fig. 2 (a) shows a state in heating mode. The inside space of the thrust-ring is made suction pressure as well as the motor chamber. Moreover, the outside space of the thrust-ring is made always suction pressure regardless of the operation mode. The backside space of the thrust-ring is made discharge pressure, and the optimum power, which pushes the orbiting scroll in the direction of an axis, is generated.

Fig. 2 (b) shows a state in cooling mode. The inside space of the thrust-ring is made discharge pressure as well as the motor chamber, and generates the axial force. If the backside space of the thrust-ring is made the same pressure, which is discharge pressure, the axial force will be too large. Therefore, the backside space of the thrust-ring is made into suction pressure, and does not generate the axial force.

## Pressure Changing Valve

The pressure of the motor chamber automatically changes the pressure of the backside space of the thrust-ring, without depending on a signal from the other equipments. The piston type valve performs the pressure of the backside space as shown in Fig. 2.

As shown Fig. 2 (a), in heating mode, the piston moves to left-hand side with the coil-spring. The backside space of the thrust-ring is connected to the discharge chamber, and the backside space becomes discharge pressure.

Fig. 2 (b) shows a state in cooling mode. The pressure of the motor chamber, which is discharge pressure, acts on the left end of the piston valve, the power by this pressure overcomes the power of the coil-spring, and the piston moves to right-hand side. The backside space of the thrust-ring is connected to the outside space of the thrust-ring, which is the suction pressure, and the backside space becomes suction pressure.

## COMPLESSOR SPECIFICATION

The main specifications of the trial production compressor are shown in Table 1. The developed hybrid type scroll compressor is for R410A of 1 HP class in vertical type, which has the compression components above a motor.

Table 1 Main specifications

| | |
|---|---|
| Refrigerant | R410A |
| Displacement volume | $10.3cm^3$ |
| Motor | Brush less DC motor<br>Concentrated winding |
| Rotational speed | 10 - 130 rps |

## COMPRESSOR COP

The measurement result of COP of the developed hybrid type scroll compressor is shown in Table 2. There was no fall of COP by adopting the change mechanism. As compared with other type compressor, higher COP was attained by scroll wrap dimension optimization in cooling mode. Although the hybrid type compressor is low-pressure operation in heating mode, COP in high-pressure operation is shown as reference in heating mode. As for low-pressure operation, COP falls compared with high-pressure operation. However, the average COP of cooling and heating mode has attained more than other type compressor.

Table 2 Compressor COP

| | Cooling mode | Heating mode | | Average of cooling and heating mode |
|---|---|---|---|---|
| | | Low-pressure operation | High-pressure operation | |
| Developed hybrid type scroll compressor | 4.52 | 3.49 | (3.70) | 4.01 |
| Scroll compressor (High-pressure type) | 4.30 | | 3.63 | 3.97 |
| Scroll compressor (Low-pressure type) | 4.07 | 3.35 | | 3.71 |
| Two cylinders rotary compressor | 4.35 | | 3.56 | 3.96 |

## SHORTENING THE STARTUP DURATION OF HEATING SYSTEM

The developed hybrid type scroll compressor was carried in the air-conditioner, and the temperature of the inside heat exchanger was measured from starting of heating operation. The measurement result is shown in Fig. 3. 40 degree-C attainment time could be made into the half compared with the case where the high-pressure type compressor is carried.

The low-pressure operation mode can shorten the startup duration of heating system since hot gas is directly discharged from the start. The high-pressure type compressor has long startup duration of heating system since hot gas is discharged after passing through the motor chamber and heating the motor.

## CONCLUSIONS

The developed compressor has achieved the compressor COP more than usual in the high-pressure operation and has made the startup duration of heating system half than usual in the low-pressure operation. Accordingly, we have confirmed the usefulness of our developed hybrid type scroll compressors.

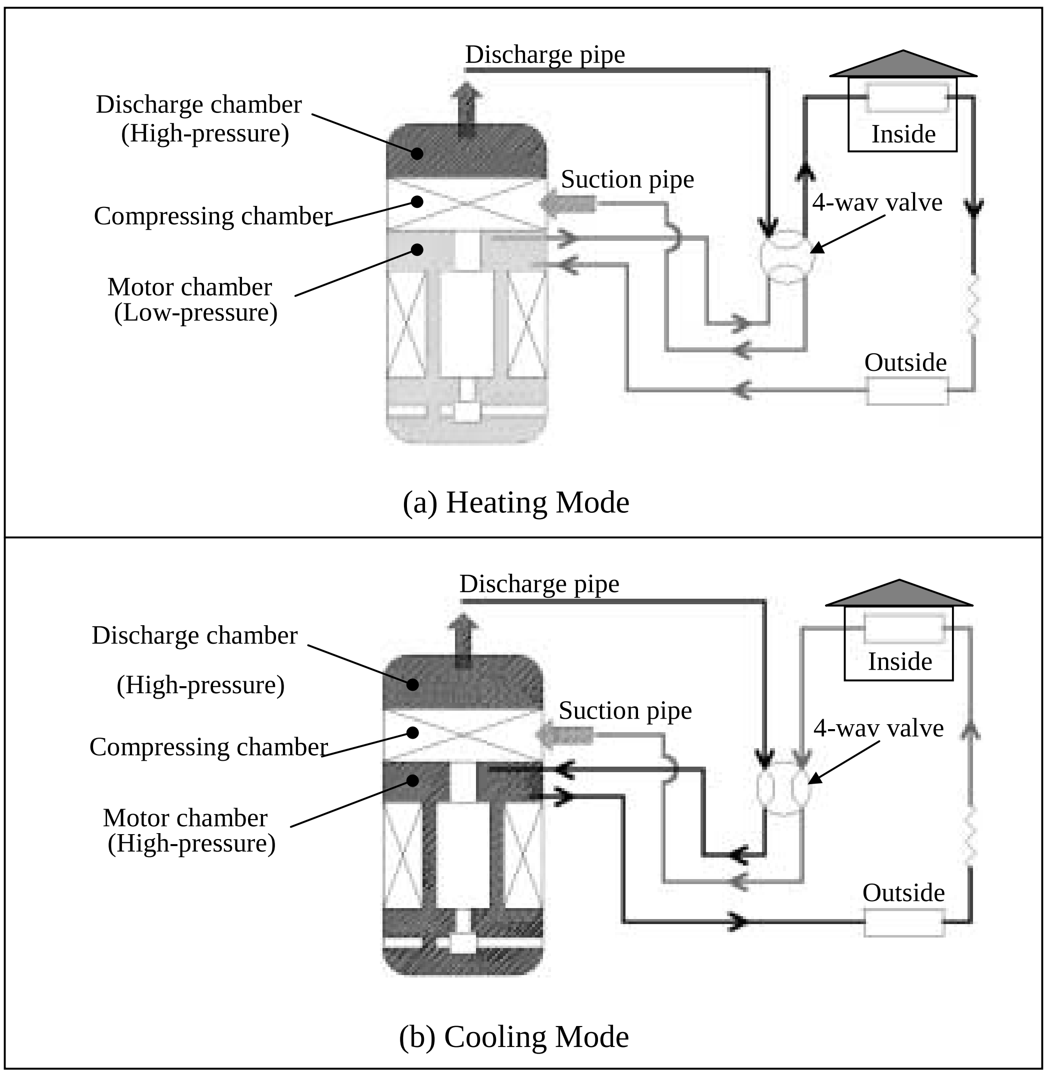
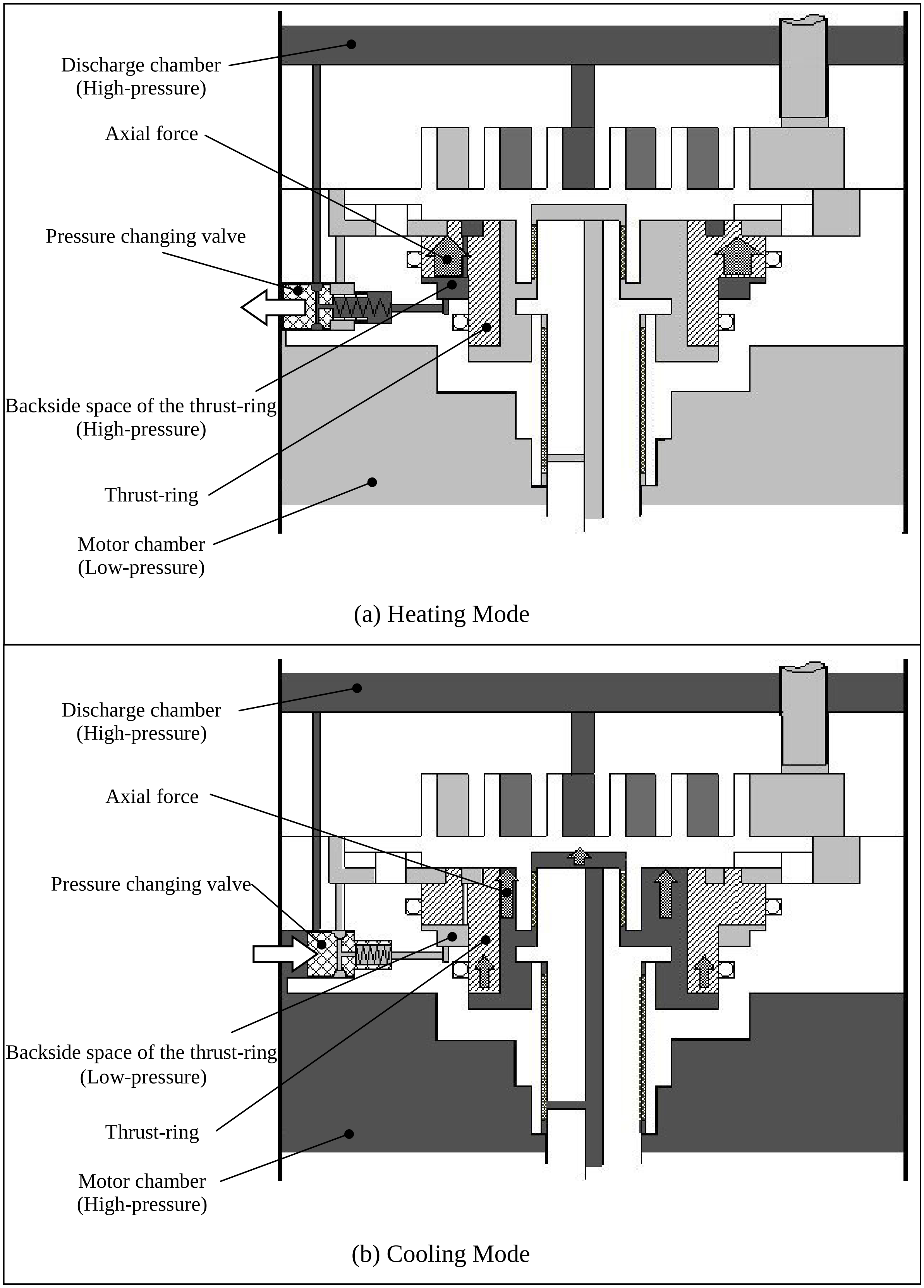



Figure 1: Pressure changing system




(a) Heating Mode

(b) Cooling Mode

Figure 2: Optimization of Axial Force

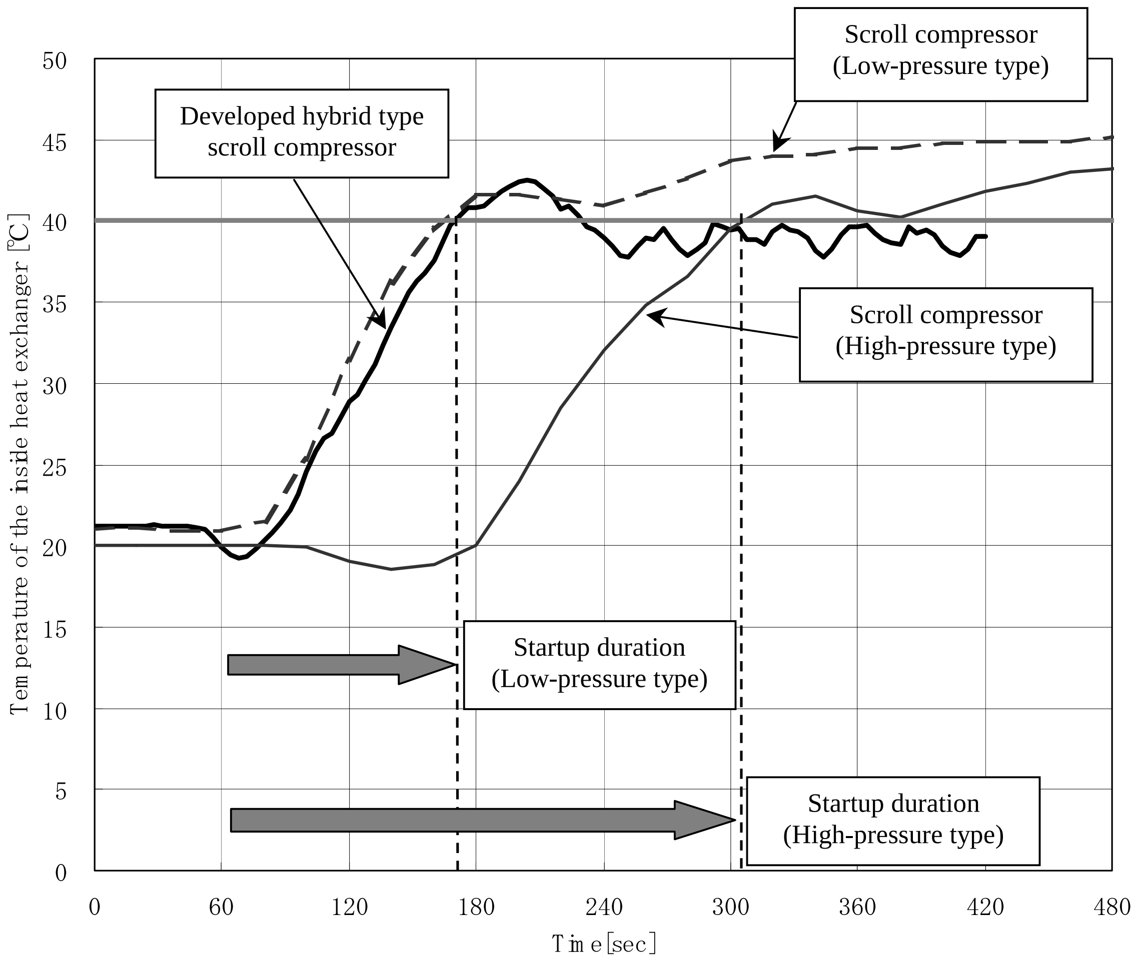



Figure 3: Comparison of the startup duration of heating system