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EXPERIMENTAL STUDY ON THE CHARACTERISTICS OF TWIN SCREW COMPRESSOR IN AIR-SOURCE HEAT PUMP SYSTEM

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ABSTRACT

In recent years, the air-source heat pump system has been widely used in a lot of air-conditioning applications due to its unique advantages. Twin-screw compressor is a very important component in this kind of system, so its performance characteristics are studied in this paper. The refrigeration capacity and power consumption are measured under various operating conditions, and the performance characteristics are investigated with different refrigerants such as R22, R134a, R404A and R407C. Moreover, the p-V diagrams indicating the thermodynamic processes of twin screw compressor are recorded, and the experimental results of the refrigerating twin screw compressor is discussed by making use of the p-V diagrams. The conclusions obtained in this paper can provide some detailed guidelines for the design of twin-screw compressor used in air-source heat pump system.

INTRODUCTION

In recent years, air-source heat pump has been widely used in central air-conditioning applications. Twin-screw compressor is a very important component in heat pump, so it affects the performance of heat pump system directly. In order to improve the performance of air-source heat pump system, it is important to study the characteristics of twin-screw compressors.

In this paper the thermodynamic performance of twin-screw compressor is investigated under various operating conditions and with different refrigerants such as R22, R134a, R404A and R407C. Moreover, the p-V diagrams indicating the thermodynamic processes of twin-screw compressor are recorded. The data obtained in the experimental research is very useful to the design of twin-screw compressor.

EXPERIMENTAL SETUP

As shown in Figure 1, the heat pump system is a 45RT air-source heat pump system with twin screw compressor. As shown in Figure 2, the SR-3H compressor’s rotational speed is 3000r/min, external diameter of male rotor is 138.5mm and female rotor diameter is 109.8mm.
In the experimental research, the refrigeration capacity and power consumption are measured under various operating conditions, and the performance characteristics are investigated with different refrigerants.

The p-V diagram is recorded with a pressure sensor, which is in the bottom of female rotor near discharge end face. When two rotors are meshing and refrigerant is compressed toward the discharge end face, the pressure variation can be measured by the sensor. The micro-sensor is XT-140-250A pressure sensor, which produced by Kulite Group. Installation of the pressure sensor and signal collect device as shown in Figure 3. The sensor is connected with JD-5 slip ring through center hole of female rotor and coupling. Signal will be collected and analyzed by the JOVIAN5200 dynamic signal analyzer. In order to measure the rotation angle of the rotor, a sensor is installed besides the coupling. So the curve of pressure varieties along with time can be recorded.
EXPERIMENTAL RESULTS AND DISCUSSION

Performance of refrigerating screw compressor in air-source heat pump is studied by the experiments as following: the heat pump system runs under the condition that evaporating temperature is 0℃ and condensing temperature is 50℃ with different refrigerant, such as R22, R134a, R404A and R407C. The effects of the economizer, frosting and defrosting on the compressor are measured and the P-V indicating diagram is recorded in the testing process.

Under various operating conditions, refrigerating capacity of heat pump system and power consumption of twin-screw compressor are measured with 4 kinds of different refrigerants as shown in Figure 4, Figure 5 and Figure 6. Comparing with R22, refrigerating capacity of R134a is declined by 41.68%, R404A increased by 3.56% and R407C increased by 5.16%. When R407C and R404A are used in heat pump system, power consumption of twin-screw compressor increased by 8.7% and 4.35% respectively relative to R22. Refrigeration capacity and
power consumption are measured, when heat pump works on 100% load, 75% load and 50% load respectively. Experiment data are shown in Figure 7, relative to 100% load. Figure 8 shows the pressure variations with time under 50% loading condition and 75% loading condition.

![Figure 8 Pressure variations along with time](image)

**A** Under 50% Loading Condition  **B** Under 75% Loading Condition

Figure 8 Pressure variations along with time

![Figure 9 Pressure Variations along with Time](image)

![Figure 10 Indicating Diagram of Compressor](image)

Pressure variation curve within the testing compressor with R22 is shown in Figure 9. The horizontal coordinate is for time t. The vertical coordinate is for pressure p. The compressor rotation speed is 2971r/min and discharge pressure is 1.885MPa. Two impulse marks indicate the rotation angle of the rotor as shown in Figure 8. Relationship between pressure and time can be transferred into relationship between pressure and male rotor angle by rotation speed. The p-V diagram of twin-screw compressor with R22 under an operating condition is shown in Figure 10. The indicated work of compressor can be calculated by the p-V diagram. Moreover, some other parameters can be calculated, for example mechanical efficiency.

Suction and discharge pressure variation of twin-screw compressor is shown in Figure 11 under defrosting condition. Pressure varies rapidly during the defrosting period. It will affect compressor performance. In the defrosting mode, the suction pressure experiences an evident decline, and it usually goes below 0.1MPa after
increasing immediately. And then the suction pressure has a slight raise. The discharge pressure experiences a rapid drop and raise during the defrosting period. The frosting of the fin in air-source heat pump is shown in Figure 12.

![Figure 11 Discharge and Suction Pressure during Defrosting](image1)

![Figure 12 Frosting Picture](image2)

Power consumption of compressor and COP of heat pump system are measured when economizer system is used, as shown in Figure 13. In this figure, subscript 1 is for R22; subscript 2 is for R407C; A is for common operating condition; B is for the pressure of the heat exchanging economizer is 0.8MPa(g); C is for the pressure of the heat exchanging economizer is 1.2MPa(g); D is for the pressure of the flashing economizer is 0.8MPa(g). Figure 11 is got by the data of other conditions relative to common operating condition.
CONCLUSIONS

(1) The power consumption of compressor, refrigeration capacity and COP of the air-source heat pump are measured under various conditions with different refrigerant, such as R22, R134a, R404A and R407C.

(2) With the aid of the pressure sensor in the bottom of female rotor, the p-V diagram of the testing compressor is recorded successfully. The performance of compressor can be analyzed by it.

(3) The suction and discharge pressure are recorded under frost and defrosting conditions. The effect of economizer on compressor performance is tested in this paper.

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