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EXPERIMENTAL INVESTIGATION OF THE
ROLLING PISTON TYPE REFRIGERATING
ROTARY COMPRESSOR WITH R502

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ABSTRACT

In this paper, the experiment of thermal performance of the compressor with R502 has been carried out at various evaporating temperatures from -30°C to +10°C and different condensing temperatures from +30°C to +55°C. The curves of main performance parameters versus evaporating temperatures have been obtained. The experimental data have been analysed. By comparison with the performance parameters of the compressor with R22, the curves of performance parameters versus evaporating temperatures have been gained. The results indicate that the compressor with R502 has an obvious improvement on energy saving at lower evaporating temperatures and higher condensing temperatures.

NOMENCLATURE

\[ \begin{align*}
  t_k & \quad \text{Condensing temperature, } ^\circ\text{C} \\
  t_e & \quad \text{Evaporating temperature, } ^\circ\text{C} \\
  t_d & \quad \text{Discharge temperature, } ^\circ\text{C} \\
  Q_o & \quad \text{Refrigeration capacity, W} \\
  N & \quad \text{Input motor power, W} \\
  E.E.R & \quad \text{Energy efficient ratio} \\
  \lambda & \quad \text{Volumetric efficiency} \\
  Q_m & \quad \text{Mass flow rate, Kg/h} \\
  \pi & \quad \text{Pressure ratio}
\end{align*} \]

INTRODUCTION

The rolling piston type refrigerating rotary compressor is widely used in small-sized refrigerating installation (i.e. domestic refrigerators and room air conditioners) because of its high efficiency, small size, light weight, few components, high productivity and so on. The compressor usually uses R12 or R22 as the refrigerant.

In order to enlarge the operating temperature range of the compressor, increase refrigeration capacity and decrease the amount of R12 used in the refrigeration installations, currently, it is very significant to investigate the performance of this kind of compressor with R502. In this paper, the experiment of the compressor with R502 has been carried out at various evaporating temperatures and condensing temperatures. And by comparing with the performance parameters of the compressor with R22, the results provide the practical basis for using the compressor with R502.

EXPERIMENTAL SYSTEM

The rated parameter of the compressor tested:
refrigeration capacity 2600 W
motor power 890 W
refrigeration used R22

The experiments of the thermal performance of the compressor have been carried out by the method of calorimeter. The compressor has operated at the conditions of evaporating temperatures from -30°C to +10°C, condensing temperatures from +30°C to +55°C. The experimental system is shown in Fig.1.

THE PERFORMANCE PARAMETERS OF THE COMPRESSOR WITH R502

1. \( Q_o, N \) And E.E.R

Fig.2 shows the relationship between \( Q_o \) and \( t_o \). From the figure, it can be seen that \( Q_o \) decreases rapidly as \( t_o \) decreases, and when \( t_K \) increases, \( Q_o \) also decreases. But the influence of \( t_o \) on \( Q_o \) is greater than that of \( t_K \) on \( Q_o \).

Fig.3 shows \( N-t_o \) curves. It indicates that there is a maximum for each curve. The maximum point moves in the direction of increasing \( t_o \) when \( t_K \) increases. \( N \) increases as \( t_K \) increases too. The higher \( t_K \), the larger the variation of \( N \) versus \( t_o \).

The curves in Fig.4 represent the relationship between E.E.R and \( t_o \). When \( t_o \) decreases, E.E.R decreases, and when \( t_K \) increases, E.E.R also decreases. The lower \( t_K \), the larger the variation of E.E.R.

2. \( \lambda \) And \( Q_o \)

Fig.5 shows the relationship between \( \lambda \) and \( t_o \). As \( t_K \) increases, \( \lambda \) decreases, and as \( t_o \) decreases, \( \lambda \) decreases considerably. The reason is that the leakage loss of lubricating oil increases rapidly.

The curves of Fig.6 represent the relationship between \( \dot{Q}_m \) and \( t_o \). It can be found that curves of \( \dot{Q}_m \) versus \( t_o \) are in a group curves with a little distance. As \( t_o \) decreases, \( \dot{Q}_m \) decreases, but as \( t_K \) increases, \( \dot{Q}_m \) decreases slightly. The influence of \( t_o \) on \( \dot{Q}_m \) is greater than that of \( t_K \) on \( \dot{Q}_m \).

3. \( t_d \)

Fig.7 shows the relationship between \( t_d \) and \( t_o \). The lower \( t_o \), the higher \( t_d \), and the higher \( t_K \), the higher \( t_d \).

COMPARING PERFORMANCES OF THE COMPRESSOR WITH R502 TO THAT OF THE COMPRESSOR WITH R22

1. The Refrigeration Capacity Ratio \( Q_o,R502 / Q_o,R22 \), The Input Motor Power Ratio \( N_{R502} / N_{R22} \) And The E.E.R Ratio \( E.E.R_{R502} / E.E.R_{R22} \)

Fig.8 shows the relationship between \( Q_o,R502 / Q_o,R22 \) and \( t_o \). It can be obtained that \( Q_o \) of the compressor with R502 is larger than that of the compressor with R22 when \( t_o \) is lower than about 0°C, and that the higher \( t_K \), the larger \( Q_o,R502 / Q_o,R22 \). The reason is that the compressor with R502 has higher suction pressure, smaller pressure ratio and suction specific volume than the compressor with R22 at the same working condition.
Fig. 9 represents the relationship between $N_{R502}$ / $N_{R22}$ and $t_0$. It is found that $N$ of the compressor with R502 is larger than $N$ of the compressor with R22, and that $N_{R502}$ / $N_{R22}$ is approximately larger than 1.05.

The relationship between $E.E.R_{R502}$ / $E.E.R_{R22}$ and $t_0$ is shown in Fig. 10. It can be obtained that $E.E.R_{R502}$ / $E.E.R_{R22}$ versus $t_0$ almost unchanged and approximately equals 1, and that all $E.E.R_{R502}$ / $E.E.R_{R22}$ are less than 1 when $t_0$ is higher than 0°C. Furthermore, $E.E.R_{R502}$ / $E.E.R_{R22}$ is much larger at lower evaporating temperatures and higher condensing temperatures, i.e. the compressor with R502 has higher efficiency than the compressor with R22.

2. The Volumetric Efficiency Ratio $\lambda_{R502}$ / $\lambda_{R22}$ And The Mass Flow Rate Ratio $\dot{Q}_{m,R502}$ / $\dot{Q}_{m,R22}$

Fig. 11 shows the relationship between $\lambda_{R502}$ / $\lambda_{R22}$ and $t_0$. It can be seen that $\lambda_{R502}$ / $\lambda_{R22}$ is approximately equal to 1 when $t_0$ is high, and when $t_K$ is low, $\lambda_{R502}$ / $\lambda_{R22}$ changes very little corresponding to $t_0$. But $\lambda_{R502}$ / $\lambda_{R22}$ is much larger at higher $t_K$ and lower $t_0$. When $t_0$ is lower than 5°C, the higher $t_K$, the larger $\lambda_{R502}$ / $\lambda_{R22}$ because the compressor with R502 has smaller pressure ratio, lower discharge temperature and oil temperature than the compressor with R22, and the solvability of R502 is larger than that of R22 in lubricating oil, which makes heat transfer loss and lubricating oil leakage loss of the compressor with R502 smaller than that of the compressor with R22 at the same $t_0$ and $t_K$.

Fig. 12 shows the relationship between $\dot{Q}_{m,R502}$ / $\dot{Q}_{m,R22}$ and $t_0$. It is found that $\dot{Q}_{m}$ in the cycle using R502 is always larger than that in the cycle using R22, and $\dot{Q}_{m,R502}$ / $\dot{Q}_{m,R22}$ is about 1.5. The reason is that the compressor with R502 has higher suction pressure, smaller suction specific volume and pressure ratio than the compressor with R22 at the same working condition.

3. The Discharge Temperature Difference $t_{d,R22}$ - $t_{d,R502}$

The relationship between $t_{d,R22}$ - $t_{d,R502}$ and $t_0$ is shown in Fig. 13. It is seen that $t_0$ of the compressor with R502 is always lower than that of the compressor with R22, and the higher $t_K$, the larger $t_{d,R22}$ - $t_{d,R502}$. The cause may be that R115 is a refrigerant with larger specific heat capacity and smaller isentropic exponent in R502, and R502 has smaller pressure ratio.

Because the compressor with R502 has larger mass flow rate and heat capacity, lower discharge temperature than the compressor with R22, the motor of small-sized hermetic rolling poston type rotary compressor can be well-cooled, the motor efficiency can be improved, the temperature increase of motor and oil is small. In addition, R502 corrodes motor insul ate materials, rubbers and plastics less than R22 does, So that the life of the refrigerator can be prolonged, the fare for mending and operating can be decreased, and the reliability of the compressor can be improved.

**THE RELATIONSHIP BETWEEN THE PRESSURE RATIO $\pi$ AND THE E. E. R OR THE VOLUMETRIC EFFICIENCY $\lambda$ OF THE COMPRESSOR WITH R502**

As shown in Fig. 14, the relationship of all experimental points of E. E. R versus $\pi$ indicates that experimental points at various $t_K$ is basically located in the same curve, in other words, E. E. R values is approximately constant if $\pi$ is the same, at various working conditions. For the compressor tested, the relationship between E. E. R and $\pi$ is drawn out:

$$E. E. R_{R502} = 12.910 \times \pi^{-1.3167}$$

Fig. 15 shows the relationship of all experimental points of $\lambda$ versus $\pi$. It can be seen that the experimental points are approximately located in the same line. For the compressor tested, the rela-
tionship between $\lambda$ and $\pi$ can be expressed as:

$$\lambda_{R502} = 1.060 - 0.0670 \times \pi$$

The maximum deviation of E. E. R and $\lambda$ values measured from the correlations is within $\pm 15\%$

CONCLUSIONS

1. Substituting R502 for R22, it is turned out that the compressor with R502 has higher $Q_0$ and $\lambda$, lower $t_d$, so that the reliability of the compressor can be improved, and the life of the compressor can be prolonged.

2. Using R502 in the compressor has an obvious significance at lower $t_0$ and higher $t_X$.

3. The experimental data indicate that there are a particular corresponding relationship between E. E. R and $\pi$ and a linear relationship between $\lambda$ and $\pi$ for the rolling piston type refrigerating rotary compressor. These relationships are expressed as two correlations, i.e. E. E. R $R_{R502}(\pi)$ and $\lambda_{R502}(\pi)$.

REFERENCE

Fig. 1  Experimental System
1. Calorimeter 2. Compressor 3. Condenser

Fig. 2  $Q_o - t_o$ Curves.

Fig. 3  $N - t_o$ Curves.

Fig. 4  E.E.R - $t_o$ Curves.

Fig. 5  $\lambda - t_o$ Curves.

Fig. 6  $\dot{Q_m} - t_o$ Curves.
Fig. 7  $t_0-t_a$ Curves.

Fig. 8  $Q_{o,R502}/Q_{o,R22}-t_0$ Curves.

Fig. 9  $N_{R502}/N_{R22}-t_0$ Curves.
Fig. 10  $\frac{E.E.R_{222}/E.E.R_{22}}{t_0}$ Curves.

Fig. 11  $\frac{\lambda_{R22}/\lambda_R}{t_0}$ Curves.

Fig. 12  $\frac{Q_{m,R502}/Q_{m,R22}}{t_0}$ Curves.
Fig. 13 \((t_{a,RZ2} - t_{a,R92}) - t_o\) Curves.

Fig. 14 The Relationship of E.E.R Versus \(\pi\).

Fig. 15 The Relationship of \(\lambda\) Versus \(\pi\).