Experimental Investigation of the Rolling Piston Type Refrigerating Rotary Compressor with R502

H. Zhang
Xi'an Jiaotong University; P. R. China

B. Yu
Xi'an Jiaotong University; P. R. China

M. Xu
Xi'an Jiaotong University; P. R. China

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

Zhang Huajun   Yu Bingfeng   Xu Mingyao
Lecturer   Associate professor   Research Assistant
Dept. of Power Machinery Engineering, Xian
Jiaotong University, Xian, Shaanxi, P.R.of China

ABSTRACT

In this paper, the experiment of thermal performance of the compressor with R502 has been carried out at various evaporating temperatures from −30℃ to +10℃ and different condensing temperatures from +30℃ to +55℃. 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

t_K	Condensing temperature, ℃
t_o	Evaporating temperature, ℃
t_d	Discharge temperature, ℃
Q_o	Refrigeration capacity, W
N	Input motor power, W
E.E.R	Energy efficient ratio
λ	Volumetric efficiency
$\dot{Q}_m$	Mass flow rate, Kg / h
π	Pressure ratio

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℃ to +10℃, condensing temperatures from +30℃ to +55℃. 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. λ And $\dot{Q}_m$

Fig.5 shows the relationship between λ and t_o. As t_K increases, λ decreases, and as t_o decreases, λ 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℃, 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_o . 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_o is shown in Fig.10. It can be obtained that $E.E.R_{R502}/E.E.R_{R22}$ versus t_o almost unchange and approximately equals 1, and that all $E.E.R_{R502}/E.E.R_{R22}$ are less than 1 when t_o is higher than 0℃ . 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_o . It can be seen that $\lambda_{R502}/\lambda_{R22}$ is approximately equal to 1 when t_o is high, and when t_K is low, $\lambda_{R502}/\lambda_{R22}$ changes very little corresponding to t_o . But $\lambda_{R502}/\lambda_{R22}$ is much larger at higher t_K and lower t_o . When t_o is lower than 5℃, the higher t_K, the larger $\lambda_{R502}/\lambda_{R22}$ because the compressor with R502 has smaller pressare 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_o and t_K.

Fig.12 shows the relationship between $\dot{Q}_{m,R502}/\dot{Q}_{m,R22}$ and t_o . 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_o is shown in Fig.13. It is seen that t_d 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 hermetric 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 insulate 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 π AND THE E. E. R OR THE VOLUMETRIC EFFICIENCY λ OF THE COMPRESSOR WITH R502

As shown in Fig. 14, the relationship of all experimental points of E. E. R versus π 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 π is the same, at various working conditions. For the compressor tested, the relationship between E. E. R and π is drawn out:

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

Fig. 15 shows the relationship of all experimental points of λ versus π. It can be seen that the experimental points are approximately located in the same line. For the compressor tested, the relationship between λ and π can be expressed as :

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

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

REFERENCE

Wu Zhishun, "Simulating and Analysing of the Working Process of the Rolling Piston Type Refrigerating Rotary Compressor", M. S. Thesis, Power Machinery Dept. Xi'an Jiaotong University, 1987.

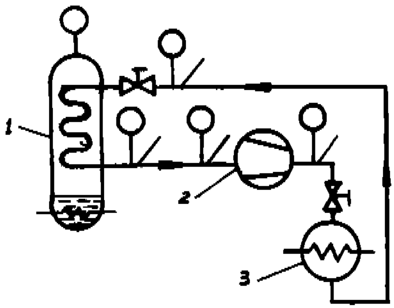

Fig.1 Experimental System
1. Calorimeter 2. Compressor 3. Condenser

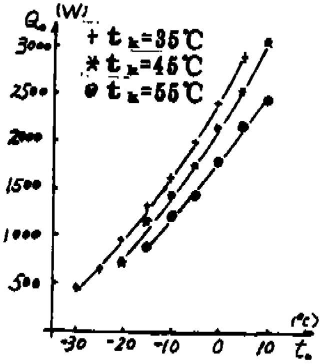

Fig.2 $Q_o - t_o$ Curves.

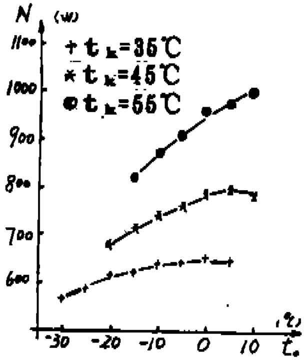

Fig.3 $N - t_o$ Curves.

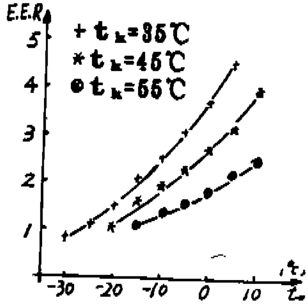

Fig.4 E. E. $R - t_o$ Curves.

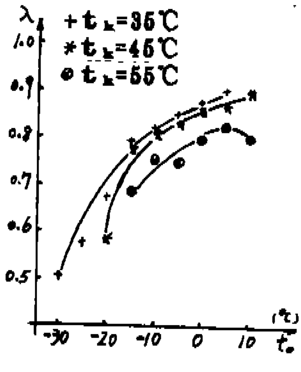

Fig.5 $\lambda - t_o$ Curves.

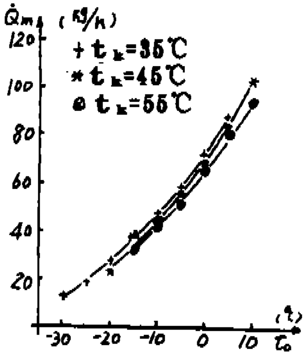

Fig.6 $\dot{Q}_m - t_o$ Curves.

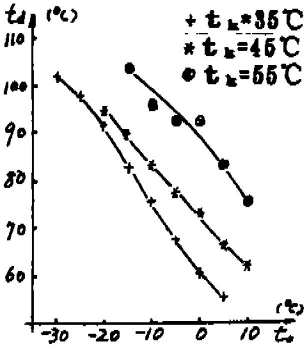

Fig.7 $t_d - t_o$ Curves.

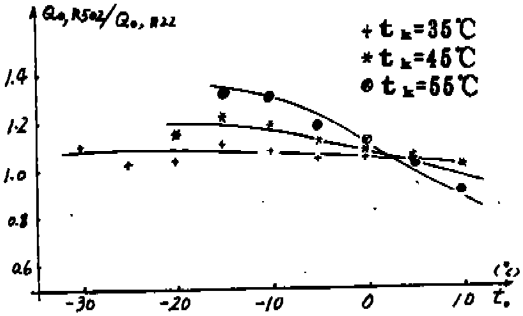

Fig.8 $Q_{o,R502}/Q_{o,R22} - t_o$ Curves.

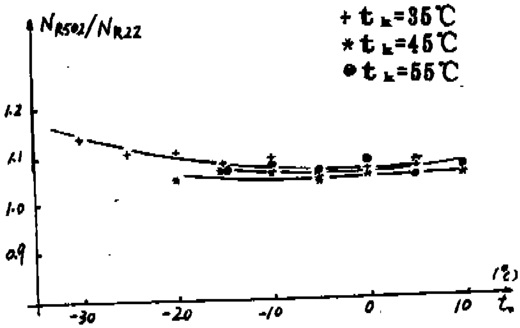

Fig.9 $N_{R502}/N_{R22} - t_o$ Curves.

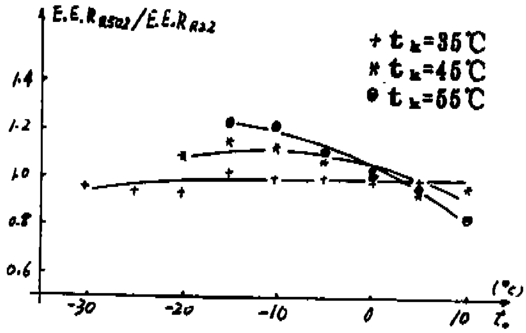

Fig. 10 E. E. R_{R502} / E. E. R_{R22} $-t_o$ Curves.

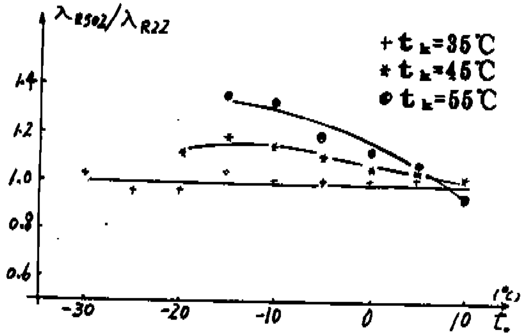

Fig.11 λ_{R502} / λ_{R22} $-t_o$ Curves.

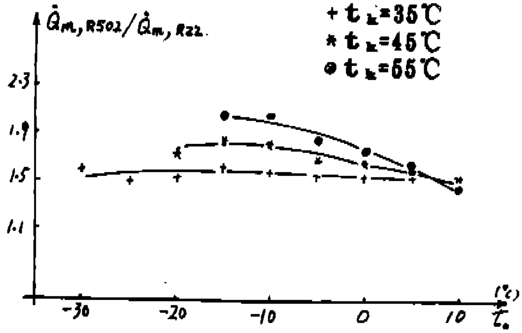

Fig.12 $\dot{Q}_{m,R502}$ / $\dot{Q}_{m,R22}$ $-t_o$ Curves.

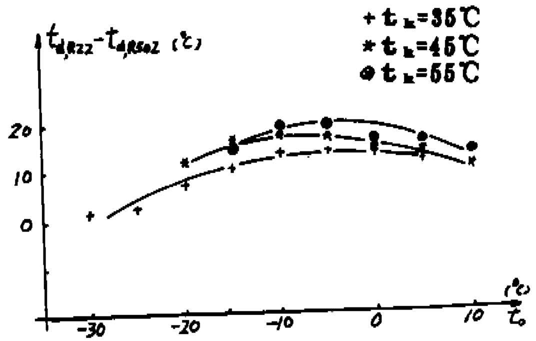

Fig.13 $(t_{d,R22} - t_{d,R502}) - t_o$ Curves.

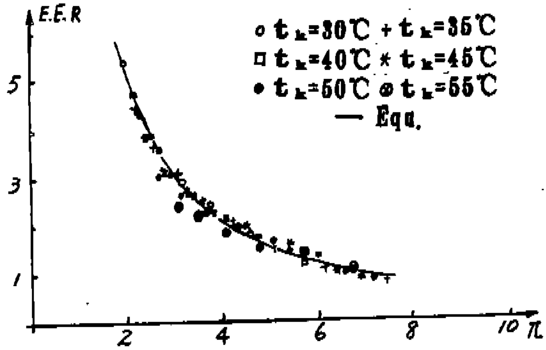

Fig.14 The Relationship of E. E. R Versus π.

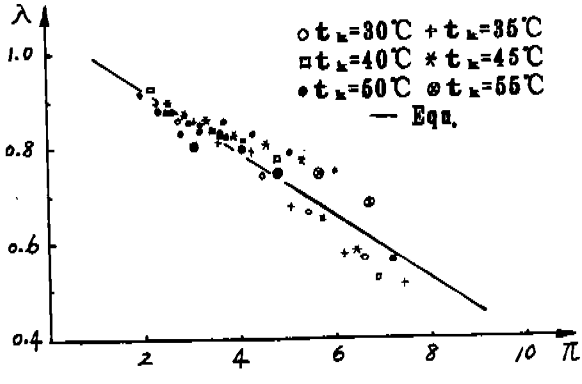

Fig.15 The Relationship of λ Versus π.