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KEY PROBLEMS OF THE TESTS DURING THE DEVELOPMENT OF ROLLING PISTON COMPRESSORS FOR ROOM AIR CONDITIONERS USING R407C AS REFRIGERANT

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ABSTRACT

This paper mainly introduces the test work during the development of rolling piston compressor using R407C as refrigerant, analyzes some key problems including how to decide the test conditions, water control in the test system and the correct charging method of R407C.

Keywords: rolling piston compressor, Refrigerant of R407C

INTRODUCTION

R22 is most frequently used among HCFCs refrigerants, which is energy effective, safe and has good thermodynamic properties as well as high refrigeration capacity. As a result, R22 is widely used in refrigeration and air-conditioning fields including high temperature, intermediate temperature and low temperature applications. But because R22’s ODP is 0.05, it is still harmful to the Ozone layer and should be replaced by those with zero ODP. As a possible alternative refrigerant for R22, it must meet the following requirements:

(1) ODP=0; (2) with no harm or very little harm; (3) non-flammable; (4) chemically and thermally stable; (5) with the same or similar thermodynamic properties compared to R22; (6) compatible with metal and organic material as well as lubricant in the refrigeration system; (7) economical; (8) short stay period in the atmosphere; (9) GWP is zero or as small as possible.

At present, many scholars and companies from Europe and USA propose the use of HFCs refrigerants to replace R22. However, none of the HFCs refrigerants has comparative properties which compared to R22. So people phase-in HFC based combinative refrigerant R407C, which is combination of R32, R125 and R134a. It is considered to be one of the ideal alternative refrigerants for R22.
OUTLINE OF THE TESTS

The following experiments should be completed in order to test the performance and reliability of the rolling piston compressor for room air conditioner using R407C and POE lubricant.

Performance Tests:
- Capacity test
- Voltage variation test
- Over load test
- Over load and stopping voltage test
- Starting voltage test

Life Tests:
- Occlusion test
- High pressure running test
- Long term life test

KEY PROBLEMS OF THE TESTS

1. Three methods to decide test conditions

Temperature Parallelism Principle is applied to decide the test conditions for R407C, that is to decide the test temperature condition for R407C according to that for R22.

However, R407C is a non-azeotropic refrigerant and has temperature glide, that is, its temperature can be variable during evaporation or condensation process. To apply the above Temperature Parallelism Principle, we must firstly decide how to choose the temperature point of R407C. Here are three methods to choose the
temperature point of R407C to apply Temperature Parallelism Principle. Using different temperature point can lead to different test conditions. Therefore we totally have three methods to decide test conditions.

Taking compressor capacity test condition for example, the following clarifies the three methods to decide test conditions for air conditioner compressor using R407C.

As shown in Fig. 1, standard capacity test condition for R22 is:

- Condensation temperature $t_k = t_3 = 54.4 \cdot ^\circ C$
- Evaporation temperature $t_e = t_4 = t_5 = 7.2 \cdot ^\circ C$
- Pressure ratio $\pi = \frac{p_k}{p_0} = 3.44$

Here $p_k$ represents condensation pressure while $p_0$ represents evaporation pressure.

The three methods for R407C is as follows: (As shown in Fig.2)

Method 1:

Condensation temperature for R407C is decided by the mean temperature of bubble point and dew point temperature under condensation pressure, that is, $t_k = \frac{(t_2 + t_3)}{2}$. Meanwhile, evaporation temperature is the mean temperature of evaporator inlet temperature and dew point temperature under evaporation pressure, that is, $t_e = \frac{(t_4 + t_5)}{2}$.

Applying Temperature Parallelism Principle, we can get test conditions for R407C according to those for R22.

- Evaporation temperature $t_e = \frac{(t_4 + t_5)}{2} = 7.2 \cdot ^\circ C$
- Condensation temperature $t_k = \frac{(t_2 + t_3)}{2} = 54.4 \cdot ^\circ C$
- Pressure ratio $\pi = \frac{p_k}{p_0} = 3.7$

Method 2:

Condensation temperature for R407C is still decided by the mean temperature of bubble point and dew point temperature under condensation pressure, that is, $t_k = \frac{(t_2 + t_3)}{2}$. Evaporation temperature is also the mean temperature of bubble point and dew point temperature under evaporation pressure, that is, $t_e = \frac{(t_4 + t_5)}{2}$.

Applying Temperature parallelism principle, we can get test conditions for R407C according to those for R22.

- Evaporation temperature $t_e = \frac{(t_4 + t_5)}{2} = 7.2 \cdot ^\circ C$
- Condensation temperature $t_k = \frac{(t_2 + t_3)}{2} = 54.4 \cdot ^\circ C$
- Pressure ratio $\pi = \frac{p_k}{p_0} = 3.645$

Method 3:

Condensation temperature for R407C is dew point temperature under condensation pressure, that is, $t_k = t_2$. Meanwhile, evaporation temperature is dew point temperature under evaporation pressure, that is, $t_e = t_5$.

Applying Temperature Parallelism Principle, we can get test conditions for R407C according to those
for R22.

Evaporation temperature $t_0 = t_e = 7.2^\circ C$

Condensation temperature $t_k = t_p = 54.4^\circ C$

Pressure ratio $\pi = p_k/p_0 = 3.746$

2. **Water control in the test system**

Due to many possible reasons, water may enter and stay in the test system. The existence of water has bad effect on the experiments. Proper measures should be taken to control water in the test system.

POE oil is used in compressors for R407C and it can absorb water more easily than mineral lubricant used in compressors for R22. When the POE oil container is open to the air, it can easily absorb the water in the air so as to result in the rust of some parts of the test system. Meanwhile, POE oil can oxidize when it contacts the air. Such oxidization can speed the hydrolyzing of the POE oil and finally result in the copper plating of the pump part of the compressor. So, when container is opened, the POE oil should be used at once and then the container should be reliably separated from the air as soon as possible.

The frequency and time of vacuumizing of the refrigeration system should be increased so as to acquire the proper vacuum level. The following measures should be taken to reduce the rudimental water in the test system.

- Vacuumize the system for a long time, about 4 hours.
- Charge proper amount of high pressure nitrogen into the system and keep it in the system for more than 24 hours.
- Discharge the nitrogen in the system and again vacuumize the system for a long time, about 4 hours.
- Repeat the above steps 4 to 5 times.

Thus the rudimental water in the system can be reduced to a very little amount and will have little effect on the test results.

In addition, the old desiccant should be changed before a new round of test will start in order that the desiccant can normally work.

3. **Charging of R407C**

Because R407C is a non-azeotropic refrigerant composed of 3 HFC refrigerants, it is very important to assure the correct charging method and charging amount.

The main procedures of the charging of R407C is as follows:

Install the compressors to be tested, which have been charged POE oil, onto the test bench. Connect compressors to the test system and vacuumize the test system to $500\mu mHg$ (0.14KPa). Then stop vacuumizing
and observe whether the system can keep the vacuum level. If it can not, that demonstrates the system maybe leak. Then find the leak points and repair them and then vacuumize the system again. Repeat the above steps till the system can keep the vacuum level.

R407C should be charged into the system as liquid to keep the proportion of its three component refrigerants as a constant. There is a dip-in pipe dipping into the bottom of the R407C container, so R407C can be charged when the container is erect. It is clear that the charging method of R407C is completely different from that of R22.

The charging amount of R407C should be properly controlled. Generally speaking, the charging amount of R407C is less than that of R22 under the same working condition. In most systems, the optimal charging amount of R407C is 90-95% of that of R22 under the same working condition.

CONCLUSION

In order to successfully develop rolling piston compressors for room air conditioners using R407C, enough attention should be paid to some key problems of the tests. These key problems include how to decide the test conditions, water control in the test system and the correct charging method of R407C. The measures mentioned in this paper to solve these key problems are very helpful to the development of rolling piston compressors for room air conditioners using R407C.

REFERENCES
