Influence of Lubricant on Rotary Compressor Using R407C

Y. Xu  
*Shanghai Hitachi Electrical Appliances Co.*

C. Zhao  
*Shanghai Hitachi Electrical Appliances Co.*

Z. Su  
*Shanghai Hitachi Electrical Appliances Co.*

Follow this and additional works at: [https://docs.lib.purdue.edu/icec](https://docs.lib.purdue.edu/icec)

[https://docs.lib.purdue.edu/icec/1406](https://docs.lib.purdue.edu/icec/1406)

This document has been made available through Purdue e-Pubs, a service of the Purdue University Libraries. Please contact epubs@purdue.edu for additional information.  
Complete proceedings may be acquired in print and on CD-ROM directly from the Ray W. Herrick Laboratories at [https://engineering.purdue.edu/Herrick/Events/orderlit.html](https://engineering.purdue.edu/Herrick/Events/orderlit.html)
INFLUENCE OF LUBRICANT ON ROTARY COMRESSOR USING R407C

Xu Ying, Zhao Chan, Su Zhijun
R&D Center, Shanghai Hitachi Electrical Appliances Co., LTD
1051, Yunqiao Rd, Pudong Jinqiao, Shanghai, 201206, P.R. China

ABSTRACT

The selection of lubricant is a key point in developing rotary compressor using R407C as a substitute for R22. The viscosity of oil, miscibility with refrigerant, thermal stability and compatibility with motor materials, etc, are all considerations. Furthermore, by reason of the POEs are more hygroscopic than mineral oils, hydrolytic stability and hygroscopicity of the selected oil must be considered seriously. This paper describes our effort to develop rotary compressor using R407C and some essential factors that should be considered. After 2000 hours durability test of compressor, the disassembly is carried on, the measurement of compressor components and the analysis of lubrication are taken. Finally, the conclusions are drawn based on these analysis. Because of the hygroscopicity of POE and the differences between R407C and R22 applications, some changes ought to be taken in the assembly line of compressor. This paper also introduces the factors which should be considered in the assembly line.

INTRODUCTION

Under the Montreal protocol, it is necessary to phase out R22 in refrigeration system. The most suitable candidates to replace R22 in rotary compressors are R407C and R410A. The substitution of R407C to R22 in compressor of room air conditioner makes it unsuitable to use mineral oil in the compressor. One of the lubricants which are fitted to be used in R407C refrigeration system is POE(Polyol ester) oil. However, because of the hygroscopicity of POE, it is very important to analyze the characteristics of the chosen lubricant, including hygroscopicity, hydrolytic stability, anti-wear ability, etc. Furthermore, the adjustment of assembly line should also be considered to ensure the product.

Resulted in the higher refrigerant system pressure of R407C than R22 together with the absent of Cl atom which has the ability of anti-wear in refrigerant, the lubrication condition in the compressor is more strict. To test the durability of the compressor together with the lubricity and anti-wear ability of lubricant, the long life test of compressor has been taken. After the test, the measurement of major moving parts of compressor has been taken,
and the evaluation of oil samples (including the test of viscosity, TAN and Inductively Coupled Plasma Spectroscopy, etc) has been done. According to these data, the conclusion has been drawn. Compared with the same type of R22/MO compressor, wear at major moving parts, such as vane, roller, the vane-roller contact, shaft, etc, of R407C/POE compressor is more severe. As a result, the modification of the structure and material of main components should also be considered.

Moreover, considering the hygroscopicity of POE and the higher system pressure of R407C than R22, the criterion of pressure, water content, the quantity of impurity of assembly line should be reestablished.

**EXPERIMENT**

**Before Modification**

To test the durability of compressor, the 2000 hours long life test is necessary. The operating conditions are as follow:

- **Suction Temperature**: 25°C
- **Environmental Temperature**: 43°C
- **Condensation Temperature**: 54.4°C
- **Evaporation Temperature**: 7.2°C
- **Duration**: 2160hrs
- **Refrigerant**: R407C
- **Lubricant**: POE
- **Compressor**: Rotary Compressor in Room Air Conditioner

POE oils from three different companies are selected and named A, B, C, respectively. After the test, disassembling the compressor and comparing the result with R22/MO compressor, it can be concluded that wear at vane-roller interface and vane-slot interface on cylinder is more severe. See Figure 1. The results of compressor tests are shown in Table 1.

With regard to wear on main components of compressors using B, C oil sample is severe, analysis of oil samples after tests is taken. The results are shown in Table 2.

In addition, analyzing metal content of oil sample, it could be found that there is obvious increase of Fe in oil samples of No.2 and No.4 compressors. That is to say wear on main components of the two compressors is severe.
There is no obvious increase of other metal content except element Fe.

<table>
<thead>
<tr>
<th>Table 1. Compressor Tests Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oil Sample</td>
</tr>
<tr>
<td>Compressor</td>
</tr>
<tr>
<td>Test Condition</td>
</tr>
<tr>
<td>Duration(hour)</td>
</tr>
<tr>
<td>Test Result</td>
</tr>
<tr>
<td>Main Problem</td>
</tr>
<tr>
<td>Causation</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Table 2. Oil Sample Tests of B,C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oil Sample</td>
</tr>
<tr>
<td>Kinematic viscosity, 40°C mm²/s</td>
</tr>
<tr>
<td>Color ASTM D1500</td>
</tr>
<tr>
<td>TAN mgKOH/g</td>
</tr>
</tbody>
</table>

*There is leakage of No.2 during operation.*

According to the results of measurement of main components and analysis of oil samples, the conclusion could be drawn as follows:

(1) Oil returns of all three POE oils are good and it shows good miscibility between the three POE oils and R407C.

(2) After the tests, electric motors are OK and there is no decomposition on motor materials and it shows good compatibility between the three POE oils and motor materials.

(3) After the tests, there is no deterioration of the three POE oils. Furthermore, TAN measured and the motor status exhibit good anti-oxidation ability of the three POE oils.

(4) After the tests, test the water content and TAN of oil samples, it could be concluded that POE oil has great hygroscopicity. Due to the hygroscopicity of POE, the control of water content in assembly line and the storage of lubricant and compressor should be paid great attention to.

(5) During the test process of R407C/POE(A) compressor, one of the causation of copper plate is the Cl atom left
in the system. Moreover, Cl in system could also mitigate the wear of main components.

(6) R407C has the more tendency of leakage than R22. Moreover, the higher pressure of R407C makes it easier to leak. Therefore, the durability of the parts which have the tendency to leak, such as valves and welds, should be reconsidered.

After Modification

In view of the wear on vane-roller contact and vane-slot interface, modification of main moving components, such as vane, roller, shaft, etc, should be taken. After modification, tests are taken and main components are measured. It is proven that after modification R407C/POE compressor has the same durability as R22/MO compressor.

CONSIDERATION OF ASSEMBLY LINE

Because of the differences between R407C/POE compressor and R22/MO compressor, for eple, the different thermodynamic properties of refrigerants, the different lubricants, the hygroscopicity of the selected lubricants, the involved points in assembly line should be reconsidered. The details are as follow:

Pressure

The pressure of leak hunting should be increased to ensure the durability of R407C/POE compressor.

Water Content

1. Water content in compressor should be controlled.
2. Special oil-charging equipment should be used.
3. Compressor should be sealed before leaving factory.
4. The principle of lubricant storage and shipping is to keep lubricant away from moisture, impurity and other contamination.
5. The storage of Lubricant should be care for.

To Control Impurity

1. To control the quantity of industrial oils residue and keep it under tolerance.
2. To control the quantity of residue of depuratives.
3. To control the acidity, alkalinity and impurity during depurating.
4. To keep the quantity of copper powder and splash under tolerance.
Others

1. The Over-Load-Relay should be changed.
2. The valves fitted in R407C system should be used.
3. Special desiccant should be used in R407C system.

CONCLUSION

The durability of R407C/POE rotary compressor has been studied. After modification the R407C/POE compressor demonstrates durability equal to R22/MO compressor. The adjustment of assembly line should be taken and some tolerance should be reestablished. Moreover some parts in system should be changed to satisfy the characteristics of R407C rotary compressor.

Figure 1. Main Wearing Components