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DEVELOPMENT OF HFC-134a COMPRESSOR FOR DOMESTIC REFRIGERATOR
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ABSTRACT

CFCs refrigerant has been phasing out quickly according to the Montreal Protocol, and alternate refrigerants have been introduced for refrigeration system. Based on the background, this time we developed new reciprocating compressor series, Model C-BZN, available for HFC-134a in refrigerators, and started production for domestic refrigerator usage. Through the development, we had several engineering issues and solved them by cooperation from all staff in design and production of compressor and refrigerator, including oil makers'. This paper presents what issues we had through the development, and how we solved the issues, especially how to cover loss of refrigeration capacity, and how to achieve appropriate reliability with new refrigeration oil in HFC-134a application.

INTRODUCTION

We selected HFC-134a as an alternate refrigerant for conventional CFC-12. The following engineering issues have to be solved in order to apply HFC-134a in refrigeration system.

- (1) To have equivalent or more refrigerating capacity compared with CFC-12
- (2) To select new refrigeration oil having compatibility with HFC-134a
- (3) To select proper compressor materials for HFC-134a
- (4) To establish proper manufacturing process for HFC-134a both in compressor and refrigerator assembly line

We have carefully researched each issue and developed new reciprocating compressor series, Model C-BZN compressor is shown in Fig. 1.

THE MAIN SUBJECT

Improvement of Compressor Performance

In comparison with CFC-12, HFC-134a has disadvantage in refrigerating capacity because of its thermodynamic property. Fig. 2 shows the calorimeter test result with conventional compressor that 15 % loss in capacity and 9 % loss in EER. To improve capacity and EER, we have changed compressor design as follows;

1. Improvement of Valves and Valve Sheet

Configuration of discharge valve, suction valve, and valve sheet has been evaluated for improving their dynamic behavior and decreasing dead clearance volume. New design aimed to improve compression and volumetric efficiency, and as a result of optimizing design, we improved by 12 % in capacity and 7 % in EER. The comparison of configuration of those parts are shown in Fig. 3.

2. Direct Suction Mechanism

As shown in Fig. 4, we applied direct suction mechanism with polymeric muffler and coil spring to improve volumetric efficiency. Direct suction mechanism brought 3 % improvement in capacity.

3. High Efficiency Motor

We designed high efficiency motor along with change of configuration of stator core so that we achieved better performance of motor in comparison with conventional one.

Selection of New Refrigeration Oil

1. Refrigeration Oil

Comparison of typical oil on properties is shown on Table 1. The biggest problem of conventional oil is not miscible with HFC-134a. Therefore we had to develop new refrigeration oil. At the beginning of development, we had researched PAG, but it was not acceptable for compressor use because of poor electrical insulation resistivity. Therefore we reached a conclusion that ester oil had the most possibility to be used in HFC-134a although we needed several improvements to cover inferior characteristics to conventional oil.

2. Development of Ester Refrigeration Oil

(1) Mechanism of Sludge Formation

We performed reliability test on refrigerators with conventional compressors manufactured based on conventional criteria, and found that sludge was formed in the refrigeration system and accumulated inside of capillary tube. Fig. 5 shows the mechanism of sludge formation in mixture of HFC-134a and ester oil. High tendency of ester oil to react with moisture and oxygen generates sludge of metal salt, and polymerized oil caused by hydrolysis, oxidation, or decomposition.

To prevent the system from sludge formation, we especially paid attention onto selection of oil that had superior thermal stability.

(2) Polyol Ester Base Oil

Ester oil is classified into polyol type and complex type. Polyol type is generally superior in anti-hydrolysis, and complex type is superior in miscibility. However, we could improve miscibility of even polyol ester oil with HFC-134a by selecting proper fatty acid. Also, concerning anti-hydrolysis, we chose appropriate composition of multivalent alcohol and fatty acid.

(3) Special Polyol Ester Oil

Although we could get excellent thermal stability by selecting appropriate polyol ester oil, we adopted special additives to achieve higher reliability of refrigerator. Fig. 6 shows accelerated test results of polyol ester degradation. It proves that special polyol ester oil with additives of A and B has superior property in degradation, and the superiority is also affirmed through various type of reliability tests.

Reliability of Compressor and Refrigeration System

1. Compatibility of Compressor Materials with Ester Oil

Organic compounds, such as motor insulation materials, suction muffler, etc., used in compressor are required to have compatibility with ester oil and HFC-134a. We adopted new enamel material of magnet wire, and also low oligomer materials of insulation film and polymeric muffler.

2. Countermeasures to Sludge Forming

We found some sludge after reliability test as mentioned above, and detected chemical elements, such as K/Ca/Si/S/Cl/Fe/Sn and Al. Then we assured that those elements were included in chemical agents and process oil used in manufacturing. Thus we confirmed that contamination control in manufacturing process was necessary and very important in both compressor and refrigerator production. We reviewed and improved our compressor manufacturing standards, and newly introduced the following production system to satisfy the new standards.

- (1) Parts Washing(Degreasing) System
- (2) Compressor Drying System
- (3) Oil Purifying System and Oil Injection System

3. Countermeasures for Wear of Compressor Parts

We adopted special polyol ester oil for HFC-134a with new compressor series, Model C-BZN. We, however, also adopted another high viscosity oil to reduce wear of compressor parts in case of that the refrigeration system was operated at considerably high load condition in catering room, or outdoor. In addition to oil improvement, we adopted specific surface treatment on sliding parts, crankshaft and piston, to improve the strength toward wear. Those countermeasures decreased drastically wear of compressor parts.

4. Chemical Specifications for Refrigeration System

To improved degradation of oil, residual moisture and air has to be strictly controlled. Therefore we newly established chemical specifications for applied products and the manufacturing process as follows,

- (1) Control of residual moisture, oxygen, and contamination mass
- (2) Installation of dryer for HFC-134a
- (3) Control of time for open to air before compressor assembled into the system
- (4) Refrigerant purifying standards and other required standards

CONCLUSION

Summary of development of C-BZN reciprocating compressor for HFC-134a application is as follows;

- (1) Development of high performance compressors for HFC-134a
- (2) Establishment of applied technology for HFC-134a refrigerant
- (3) Establishment of manufacturing technology for compressor and applied system

The established knowhow through C-BZN development for HFC-134a will be very usefull for development of NON-HCFC compressors in very near future.

ACKNOWLEDGEMENT

We wish to express our sincere thanks to all concerned people who helped us to develop new compressor series, C-BZN.

REFERENCE

- 1) T. Komatsubara, "Development of Compressor Material Technology for HFC-134a Use", 1993 Lecture at Hamamatsu area Tokai branch of JSME.
- 2) I. Iwahashi, "Compact Compressor for HFC-Refrigerant Use", Sanyo Technical Review, Vol. 26, 1994
- 3) T. Kaimai, JETI, Vol. 39, No. 3, 1991
- 4) T. Komatsubara, "Contamination Control in Refrigeration System for HFC-134a Refrigerant", 1993, Int'l Seminar on New Technology of Alternative Refrigerants

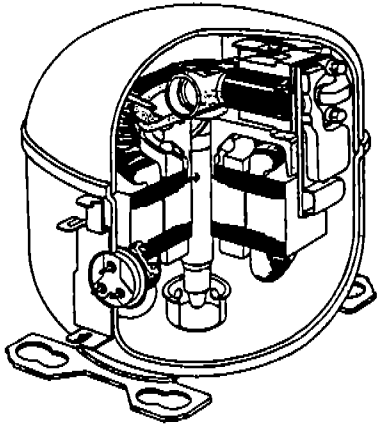


Fig. 1 C-BZN Compressor

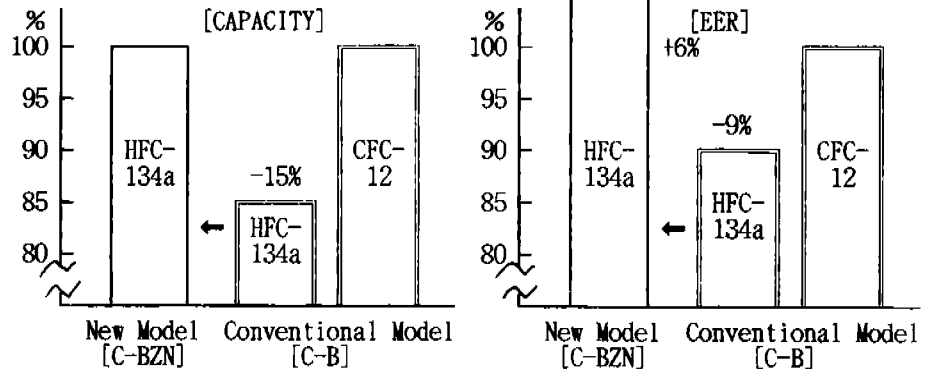


Fig. 2 Capacity & EER comparison between CFC-12 & HFC-134a
 [Cond. Temp. ; 54.4°C (130°F) / Eva. Temp. ; -23.3°C (-10°F)]

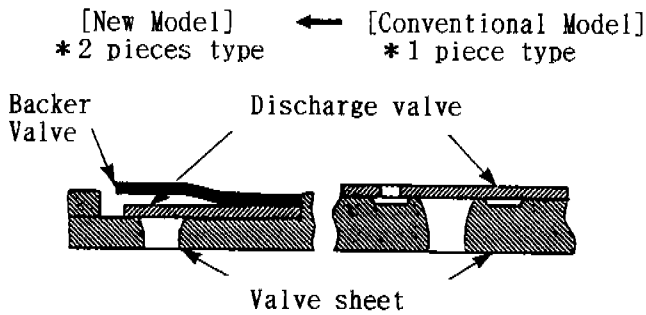


Fig. 3 Discharge valve & Valve sheet

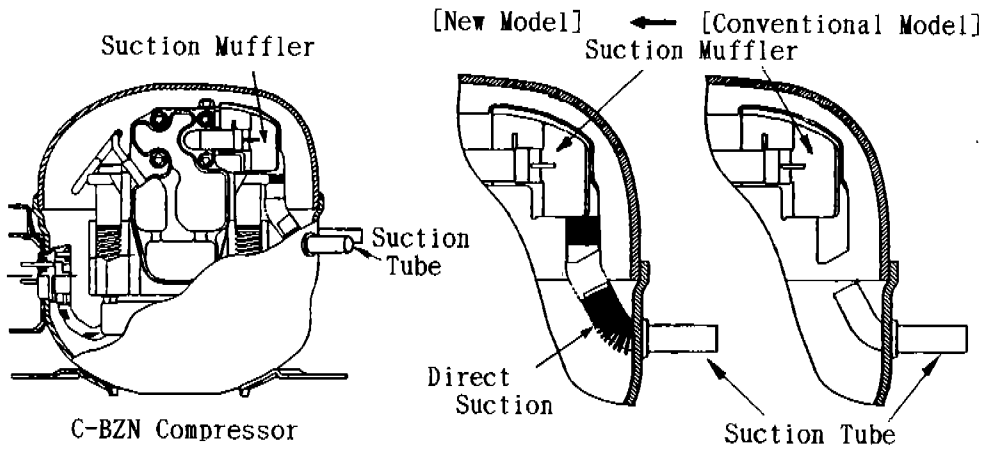


Fig. 4 New suction mechanism

Table 1 Property comparison of oils for HFC-134a

ITEM	OIL			
	Ester	Glycol	Mineral	Synthetic
Solubility	○	○	×	×
Lubrication	△	△	○	△~○
Thermal Stability	△	△	○	○
Material Compatibility	△~○	△~○	○	○
Electrical Insulation	○	×	○	○
Oxidization/Hydrolysis	△	△	○	○
Moisture Absorption	△	×	○	○

[○ ; Good, △ ; Useful, × ; Poor]

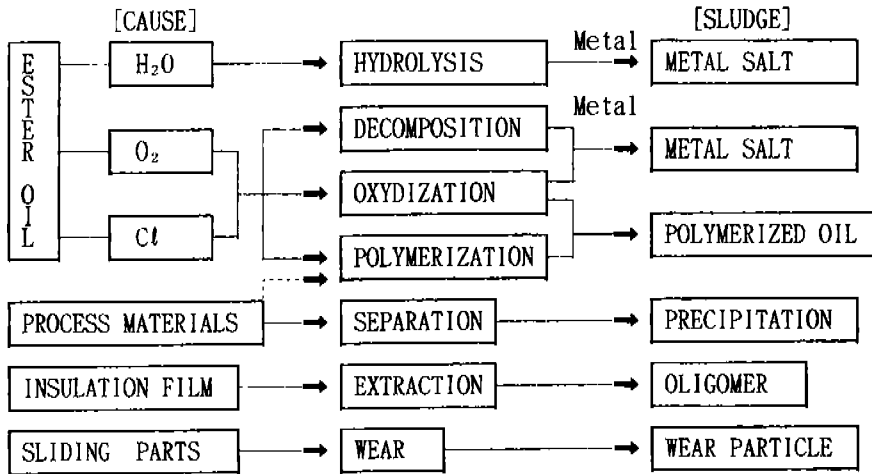


Fig. 5 Mechanism of sludge formation

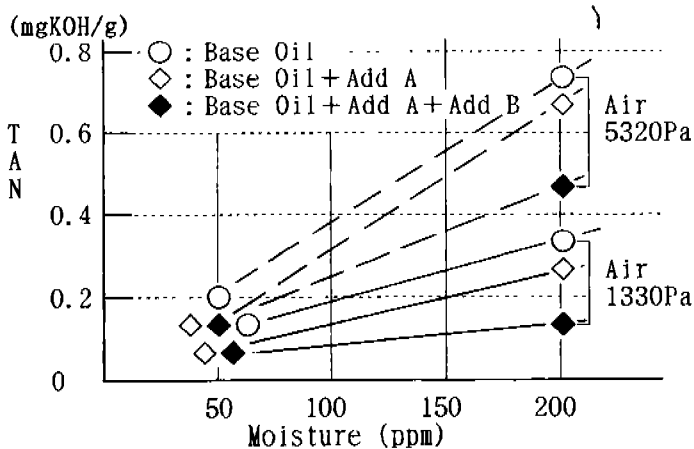


Fig. 6 Test results of ester oil degradation