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RELIABILITY STUDY OF HFC134a COMPRESSOR FOR REFRIGERATOR

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ABSTRACT

More than one year has passed since refrigerant for refrigerator was changed from CFC12 to HFC134a. Long term reliability of refrigerator in HFC134a refrigerant system is mainly dependent on lubrication of moving parts of compressor and clogging of capillary tube. To maintain better practical reliability in components in compressor such as refrigeration lubricant,metallic materials and motor insulations were evaluated.

INTRODUCTION

The results of an accelerated life test of compressor using HFC134a refrigerator have been presented. [1),2),3)] To maintain reliability of refrigerator in practical use, optimum design and production management should be applied to the refrigerant cycle regarding tribological characteristic of compressor and capillary tube clogging as shown in Fig.1. In this paper, basic techniques concerning tribology, wear property in accelerated reliability test of compressors, extraction of motor insulation materials and example of stick inside the capillary tube are examined.

STRUCTURE OF COMPRESSOR

Reciprocating type compressor is mainly used for refrigerator and representative types are scotch-york type and connecting-rod type.

Materials of bearing and moving parts of these compressors consist of steel, FC and Al Alloy. As lubricant oil, POE oil which includes anti-oxydant and acid catcher is applied.

TRIBOLOGY AND COMPRESSOR RELIABILITY

Materials and tribology

Fig.3. shows the result of Falex wear test which evaluates the relationship between moving parts of compressor and tribology.

wear property : SS(Steel)/SNC(Ni-Cr Steel)≦FC/FC<Al-Si Alloy/FC
oil influence: POE<Acid POE

POE oil temperature and wear

Fig.4 shows the result of four steel ball test which evaluates the relationship between temperature of ester oil and wear property. Wear property is remarkable in the acid condition.

(1) Influence of oil temperature on wear
(2) Property of Falex load to failure
(3) Result of accelerated reliability test

Fig.5 shows the wear property of compressor moving parts after accelerated reliability test of refrigerators which install reciprocating type compressors.

Using POE(VG15)oil with additive,wear property such as shaft/main bearing wear and piston/cylinder wear get to saturation and shows high reliability.

Property change of representative three kinds of POE oil after reliability test in refrigerator is as shown in table 1.

Change of TAN value: no change
Free fatty acid formation: less than 10 ppm each
Reaction of acid catcher: 35~94%

Motor materials and reliability in practical use

(1) Extraction of oligomer in PET film

Fig.7 shows the result of oligomer extraction from motor insulation film for compressor.

Oligomer(n=3~5) is included at 0.54% in PET-B and at 1.14% in PET-E.

Approximately 50% of oligomer(n=3~5) in PET-E is extracted after accelerated reliability test using reciprocating type compressor and approximately 5 % of oligomer(n=3~5) in PET-B is extracted after the test using rotary type compressor.

(2) Vanish extraction from magnetic wire

Vanish extraction from magnetic wire is evaluated in dipping test in HFC134a

Representative magnetic wire and test result;

PEW-AI (poly ester/amide-imide) : less than 0.1%

EIW-AI (poly ester imide/amide-imide) : less than 0.1%

Extraction matter is considered to be unreacted matter and low molecular compound.

Clogging of capillary tube

(1) Factor of capillary tube clogging

Fig.6 shows the representative sticks inside the capillary tube after reliability test in refrigerator.

POE oil,sludge of the oil,residue contaminants of process oil used for compressor and tubes and extraction matters from motor (oligomer,etc.) are mentioned as sticks.

Reliability against capillary design and manufacturing technique more strongly.

(2) Analysis of sticks

Materials of sticks inside the capillary tube can be specified by technical improvement of Micro FT-IR analysis and GC-MS analysis.

By these analyses it becomes to be possible to clear the original place where the sticks come from and control them. Representative result of capillary tube analysis and its control are as shown in table 2.

CONCLUSION

Relationship between reliability in practical use and tribology of lubricant oil combined moving parts property,refrigerant property of motor material is analyzed and reliability technique for compressor and refrigerator using HFC134a has established by optimizing design factor and factor of manufacturing technique. Also,by evaluating reliability test using sample compressors at this time,control of design and production management has proved to be correctly managed.

REFERENCE

1) T.Iizuka et al. : "Improvement of Reliability of compressors for Domestic Refrigerators using HFC134a" Proc. Int. compressor Engg. conf. at Purdue, vol.3.1992

2) A.Ishiyama et al. : "Study of technology for Refrigerant Applications. 2 Lubrication of Rotary Compressor in HFC-based Alternates" Unpublished Paper presented at 5th Int. Refrigeration Conference, July.1994

3) T.Iizuka et al. : "Performance and Tribology of a Refrigerator using Alternative Refrigerants" "TRIBOLOGIST" vol.40,No.9.1995

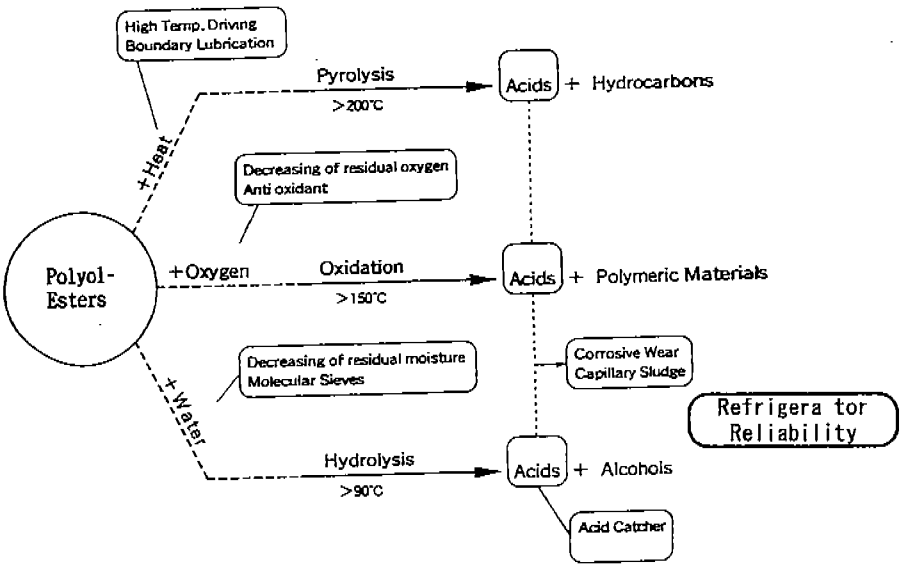

Fig. 1 Effects of POE degradation on Refrigeration Reliability

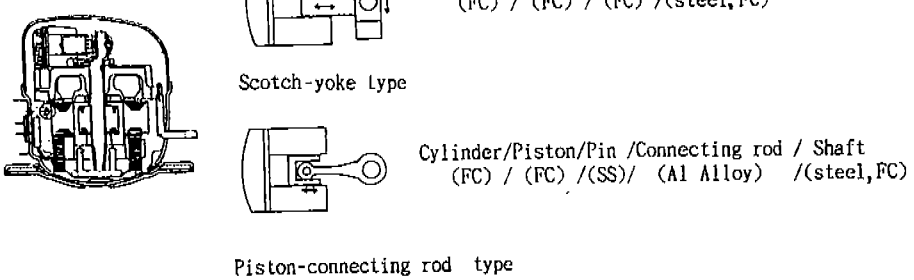

Fig. 2 Reciprocating Compressors and Sliding Materials

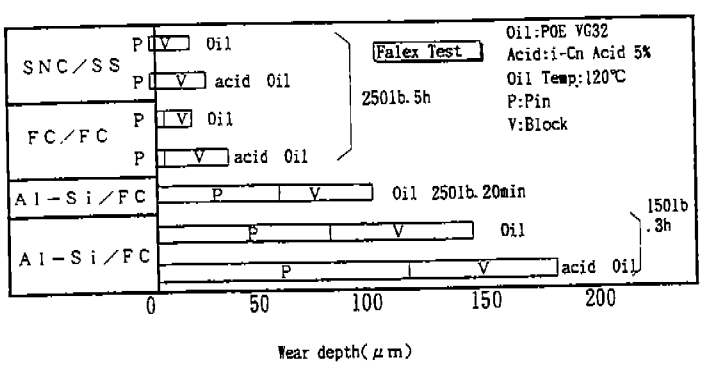

Fig. 3 Sliding Materials and Wear Property

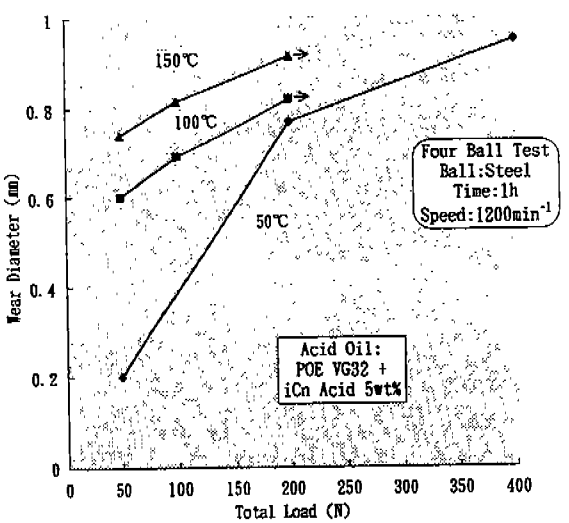

Fig. 4 Wear and Temperature with POE Oil

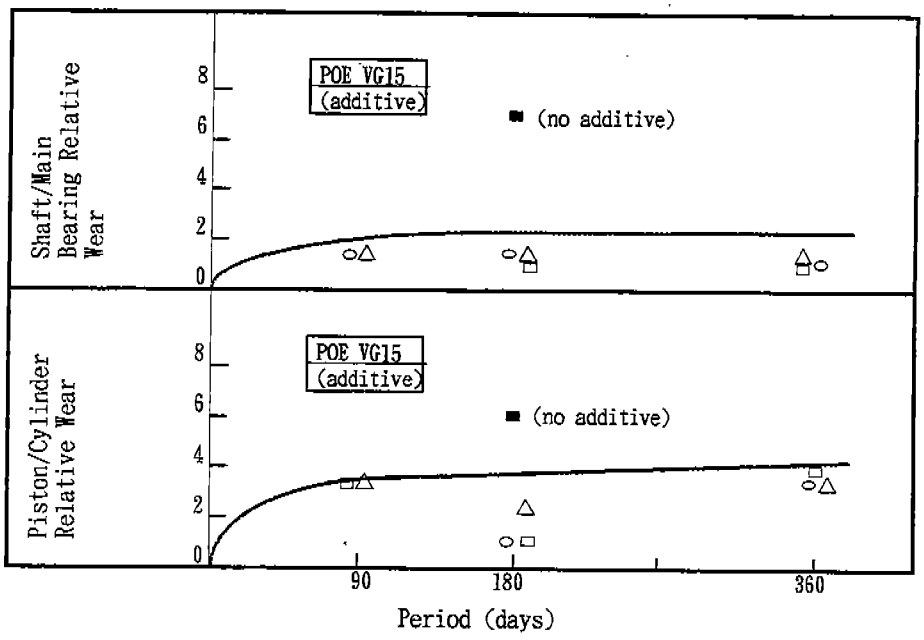

Fig. 5 Relative Wear on Refrigerator Reliability Test

Table 1 Change of Oil Property after Refrigerator Reliability Test

POE oil	Test Period (day)	Total Acid Number(mgKOH/g) 0.04 0.08 0.12	Free fatty acid (ppm) 20 40 60	Acid catching Ability (mgKOH/g) 0. 0.8 1.
VG15B	initial			
	360			
VG15A	initial			
	360			
VG15C	initial			
	360			

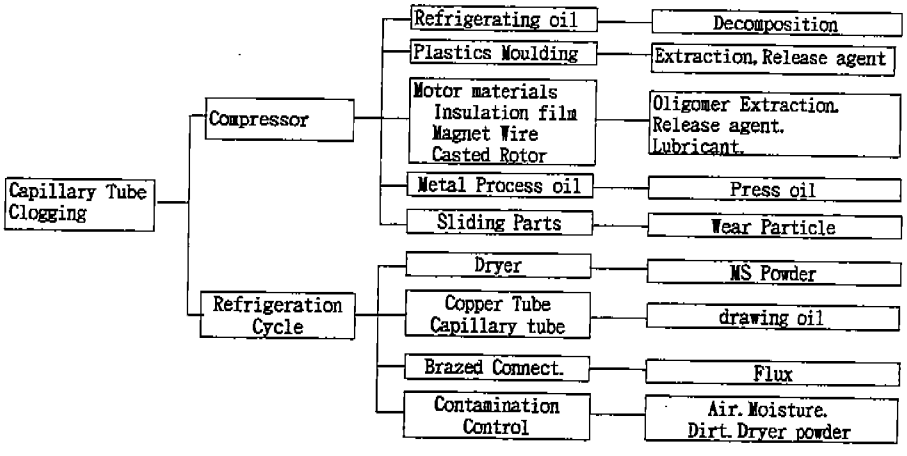

Fig. 6 Capillary Tube Clogging and Possible Cause

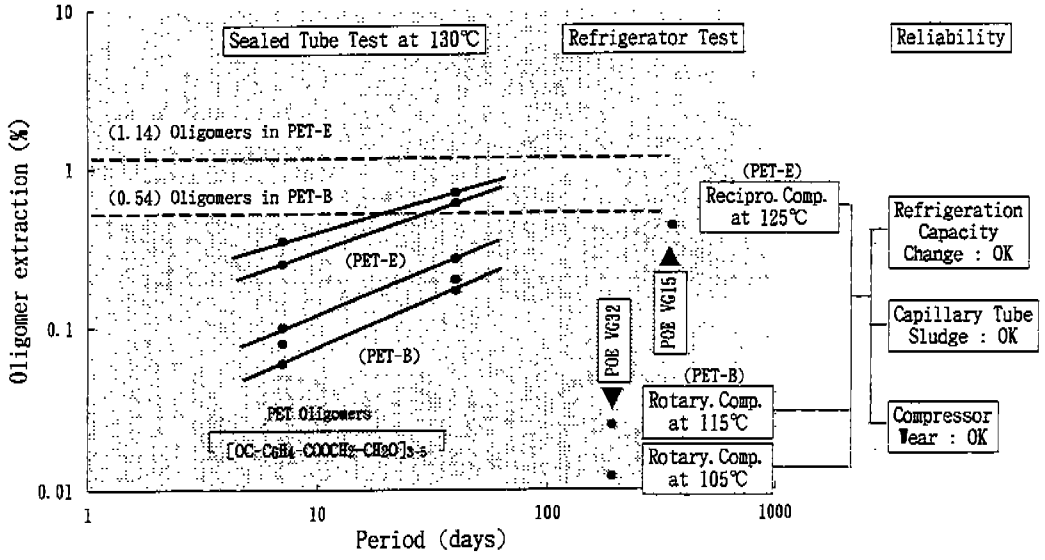

Fig. 7 Extraction of PET Oligomers and its Effects on Reliability

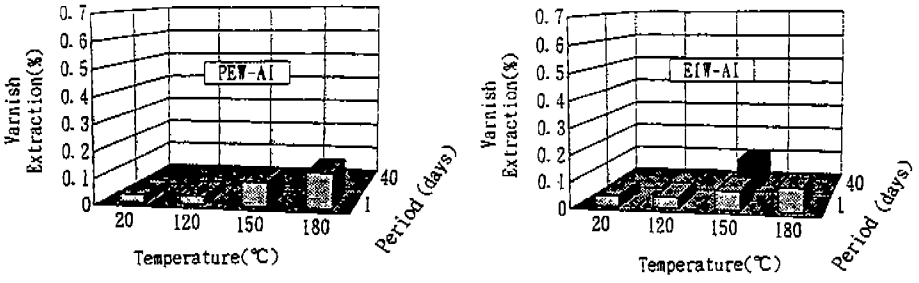

Fig. 8 Varnish Extraction from Magnet Wire

Table2 Analysis of Capillary Tube and Countermeasure

Refrigerator Test	Refrigerating Oil	Capillary Tube Point	Amount of Sludge	Hydro Carbon	Metal Carboxylate	Origanic Silicone	Petroleum Sulfonate	Poly-i-Butylene
High Temp Continuous Test	POE VG15A	Inlet	+	~Weak	Mid.	Weak Mid.	Weak	—
		Outlet	+	Strong	Weak Mid.	Weak	Mid.	—
		Connecting Tube	++	Strong	Strong	~Mid.	—	—
High Temp On/Off Test	POE VG15B	Inlet	++	Mid.	Mid.	—	—	Strong
		Outlet	Tr	—	—	—	—	—
		Connecting Tube	Tr	—	—	—	—	—
Origin Substance		Presumed		Paraffin Lubricant	Press Oil POE Oil	Releasing Agent Defoamer	Metal Press Oil	Copper Tube Drawing Oil
Countermeasure		Contaminant Control		O	O	O	O	O
		Moisture Control		—	O	—	—	—