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Reliability Measurement Technique for Evaporator used in Domestic Refrigerators

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ABSTRACT

Introduction: The evaporator used in domestic refrigerator is a heat exchanger in which the heat exchanging occurs by the mean of air. In general the reliability of evaporator is considerably high. It is seen the technical problems arising in evaporator is comparatively lesser than the other components used in it such as compressor, condenser and filter drier etc. But during long run of its use the problems arise in different components of evaporator such as due to leakage of refrigerant, choking or blockage of evaporative coil etc.

Aim and Objectives: The aim is to find the reliability of evaporator used in domestic refrigerators, working on the principle of vapour compression refrigeration system.

Material and Methods: The data used for analysis is collected from a reliable workshop and a system dynamic method is used for the analysis on Vensim-PLE modeling software.

Result: In result output table for year wise reliability of important components are shown. The comparative graph of reliability is also given to easily compare the reliability of each sub components.

Conclusion: In this research paper a newer technique is used to calculate the time based reliability of evaporator used in domestic refrigerator. This method of calculation is also applicable for all types of dynamic system. The reliability of evaporator appears almost 95.45% at the end of fifteenth year.

Key Words: Evaporator, Reliability, Refrigerant, Domestic refrigerator, Dynamic system

INTRODUCTION

Evaporator is that component of refrigerator in which actual purpose of refrigeration of commodity is fulfilled. It the part from where the actual performance of refrigeration system can also be calculated.[1],[7]

In general the evaporator used in domestic refrigerator is also known as freezer. The refrigerant flowing in the system enters in evaporator in liquid state and leaves in gaseous or vapor state. To achieve higher heat exchanging response and low material cost the evaporator is built by aluminum metal.[5]

Here the data used for reliability calculation of evaporator is collected from a certified refrigeration sales and servicing agency named as Chandra Sales which is providing its technical solution and services since last eighteen years. The data picked contains the record of 216 domestic refrigerators in which the servicing details of the evaporators and related components are given[8]. Here from the observation of log book it is clear that the reliability of evaporator is largely affected by choking or blockage of evaporative coil and leakage of refrigerant.[3,4]

MATERIALS AND METHODS

Data Collection and Measurement: The reliability measurement technique is totally based on the data collected. The

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collected data provide the average failure rate for system dynamic modeling on Vensim-PLE software.

Observation Table: Table-1

Where,

$$\lambda i = \frac{\text{No.of Complaints}}{\text{Year No.} \times 100}$$

λ_{av} **(Choking / Blockage of Evaporative Coil)**

$$= \frac{\sum \lambda i}{8}$$

$$= \frac{0{,}012}{8}$$

$$= 0.0015$$

λ_{av} **(Leakage of Refrigerant)**

$$= \frac{\sum \lambda i}{9}$$

$$= \frac{0{,}0144}{9}$$

$$= 0.0016$$

In modeling the reliability of various components of evaporator is considered as decay in these components is exponentially with time. Since all components are in different working condition, but the components considered above are most important and directly affect the reliability and performance of the evaporator.

System Dynamic Modeling of Evaporator

Reliability of Evaporator : ROE

Leakage of Refrigerant : LOR

Choking/ Blockage in evaporative coil : CEC

Programming Details

(1) CEC = EXP(-0.0015*Time)
Units: RELIABILITY

(2) FINAL TIME = 15
Units: Year
The final time for the simulation.

(3) INITIAL TIME = 0
Units: Year
The initial time for the simulation.

(4) LOR= EXP(-0.0016*Time)
Units: RELIABILITY

(5) ROE= CEC*LOR
Units: RELIABILITY

(6) SAVEPER = TIME STEP
Units: Year [0,?]
The frequency with which output is stored.

(7) TIME STEP = 1
Units: Year [0,?]
The time step for the simulation.

RESULT

Graphical Outputs for Evaporator

Output Table: Table -2

From the above data it is confirmed that choking in evaporative coil is important parameter that considerably affects the reliability of evaporator. During modification in the functioning of evaporator we must concentrate towards the rectification regarding choking of evaporative coil. From the observation table it is found that at the end of fifteenth year the reliability of choking coil falls to 97.77%. The reliability parameter like leakage of refrigerant falls to 97.62% at the end of fifteenth years which also affect the performance of evaporator.

DISCUSSION

Domestic refrigerator has four important components like evaporator, compressor, condenser and expansion devices like capillary tubes with filter drier. The reliability of overall vapour compression refrigeration system like domestic refrigerator can be calculated by calculating the reliabilities of above components separately.

CONCLUSION

Overall reliability of evaporator decreases from 100% to 95.45% at the end of fifteenth year from starting. This percentage is not feasible for confident running of vapor compression refrigeration system for fifteen years. Hence at this stage of design modification is necessary.

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Table 1: Showing failure rate of components of evaporator with time

Sl. No.	Year Interval	Choking / Blockage in evaporative coil [CEC]		Leakage of refrigerant [LOR]	
		No. of Defects	Failure Rate	No. of Defects	Failure Rate
1	0-1	-	-	-	-
2	1-2	-	-	-	-
3	2-3	-	-	-	-
4	3-4	-	-	1	λ_1=0.0012
5	4-5	-	-	3	λ_2=0.0028
6	5-6	3	λ_1=0.0023	3	λ_3=0.0023
7	6-7	-	-	1	λ_4=0.0007
8	7-8	2	λ_2=0.0012	-	-
9	8-9	4	λ_3=0.0021	-	-
10	9-10	3	λ_4=0.0014	5	λ_5=0.0023
11	10-11	1	λ_5=0.0004	-	-
12	11-12	-	-	3	λ_6=0.0012
13	12-13	4	λ_6=0.0014	3	λ_7=0.0011
14	13-14	6	λ_7=0.0020	4	λ_8=0.0013
15	14-15	4	λ_8=0.0012	5	λ_9=0.0015

Table 2: Showing the reliability of components of evaporator with time (Years)

Time (Year)	"CEC" Runs	"LOR" Runs	"ROE" Runs
0	Current 1	Current 1	Current 1
1	0.998501	0.998401	0.996905
2	0.997005	0.996805	0.993819
3	0.99551	0.995211	0.990743
4	0.994018	0.99362	0.987677
5	0.992528	0.992032	0.98462
6	0.99104	0.990446	0.981572
7	0.989555	0.988863	0.978534
8	0.988072	0.987282	0.975505
9	0.986591	0.985703	0.972486
10	0.985112	0.984127	0.969476
11	0.983635	0.982554	0.966475
12	0.982161	0.980983	0.963483
13	0.980689	0.979415	0.960501
14	0.979219	0.977849	0.957528
15	0.977751	0.976286	0.954565

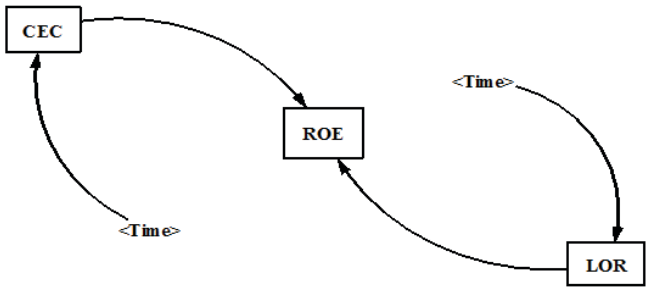

Figure 1: Showing the system modeling of evaporator used in VCRS.

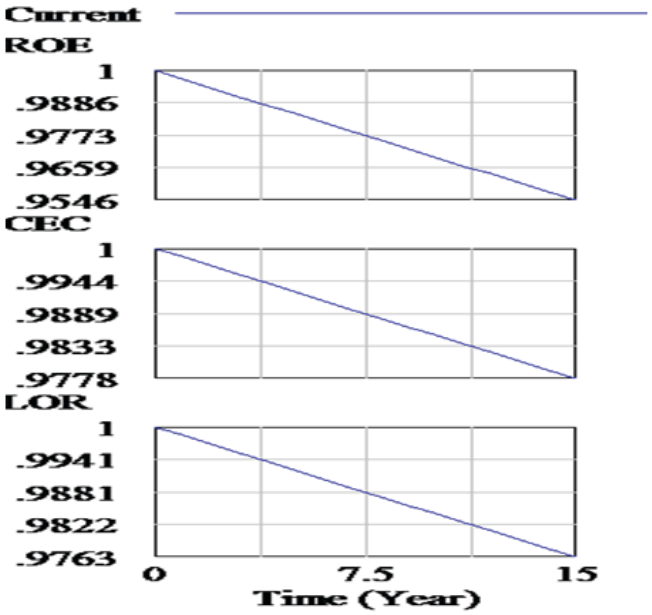

Figure 2: Comparative reliability graphs showing reliability from 0 to 15 years.