International Journal of Science and Research (IJSR)
ISSN (Online): 2319-7064
Impact Factor (2012): 3.358

Comparative Analysis of Cop Using R134a & R600a Refrigerant in Domestic Refrigerator at Steady State Condition

M.Abuzar Qureshi[1], Shikha Bhatt[2]

[1] Prestige Institute of Engineering and Science, Scheme 74 Vijay nager Indore (M.P), 452001 India

Abstract: ***The aim of this project is to comparatively analyze of COP using R134a & R600a Refrigerant in Domestic refrigerator at steady state condition. Two different refrigerant are R600a (Isobutene) and R134a (tetrafluoroethae).R134a is zero ozone depletion layer and high global warning and R600a is zero ozone depletion layer and negligible global warning. In domestic refrigerator was selected by the obtained result from R134a and an experiment using 50 g of R600a which indicate the similar result as R134a.Based on outcomes R600a charge amount, condenser evaporator and compressor coefficient of performance were selected for design. The analysis of variance result is indicated that R600a charge amount was the most effective parameter. At optimum condition the amount of charge is required for R600a was 50 g, 66% lower than R134a one, which not only being economic advantages, but also significantly reduces the of flammability of the hydrocarbon refrigerant. Thus in the present work comparatively analyze of COP using R134a & R600a Refrigerant in Domestic refrigerator at steady state condition. All the result were compared. Comparison of performance domestic refrigerator at steady state condition of the system was also studied. The result is indicate that R600a COP is mere then R134a.***

Keywords: *Isobutene, Energy consumption, Ozone depletion potential, Global warning potential, Coefficient of performance.*

1. Introduction

A Domestic refrigerator works on upon Vapors compression Refrigeration cycle. The essential component of the cycles is the evaporator, the compressor, the condenser and the expansion device. The function of compressor is to increase the pressure of the working fluid (called refrigerant) from the evaporator pressure to condenser pressure. A mechanical vapors compression (mvc) technology is use basis of many important industrial, agricultural and refrigerator and air conditioning applications. The refrigerants chlorofluorocarbon (CFCs) and hydro chlorofluorocarbon (HCFCs) both have high ozone depleting potential (ODP) and global warming potential (GWP) and con-tributes to ozone layer depletion and global warming. Therefore these two refrigerants are required to be replaced with environmentally friendly refrigerants to protect the environment. The hydro fluorocarbon (HFC) refrigerants with zero ozone depletion potential have been recommended as alternatives. R134a is the long-term replacement refrigerant for R12 because of having favorable characteristics such as zero ODP, non-flammability, stability and similar vapors pressure as that of R12 [1–2]. The ODP of R134a is zero, but it has a relatively high global warming potential. Many studies are being carried out which are concentrating on the application of environmentally friendly refrigerants in refrigeration systems. The issues of ozone layer depletion and global warming have led to consideration of hydrocarbon refrigerants such as propane, isobutene, *n*-butane or hydrocarbon blends as working fluids in refrigeration and air-conditioning systems. Hydrocarbons are designated as A3 (highly flammable) refrigerants. The hydrocarbon (HC) as refrigerant has several positive characteristics such as zero ozone depletion potential, very low global warming, non-toxicity, high miscibility with mineral oil, good compatibility with the materials usually employed in refrigerating systems.

1.1 Domestic Refrigerator

A domestic refrigerator work upon vapour compression refrigeration cycles. In vapour compression cycles are basically four basic process:

1) Isentropic compression process
2) Isobaric heat rejection process
3) Isenthalpic expansion and
4) Isobaric and isothermal heat extraction.

a) Isentropic compression process:-The Isentropic compression is shown by the line 1-2.Since the vapour is dry and saturated at the start of compression it becomes superheated at the end of compression as given by point 2.

b) Isobaric heat rejection process:-The Isobaric heat rejection process is shown by the line 2-3.The process of condensation which takes place at constant pressure line 2-3.

c) Isenthalpic expansion process:-The vapour now reduced to saturated liquid is throttle through the expansion valve and line as shown by 3-4

d) **Isobaric Process:-**The dry saturated vapour is drawn by compressor from evaporator at lower pressure P_4 and then it vapor is compressed isentropic ally to the pressure P_2.

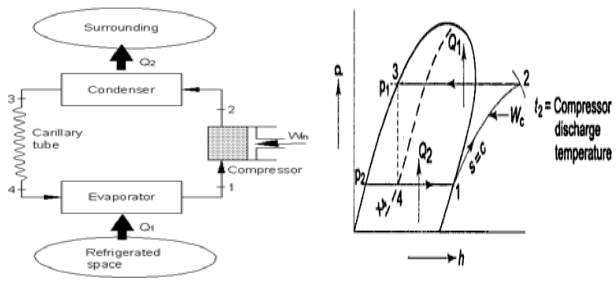


Figure1: Vapour compression cycle on P-h Diagram.

The coefficient of performance (COP) is express COP or coefficient of performance which define as

$$COP = \frac{\text{Refrigerant effect}}{\text{Compressor work}}$$

The actual COP is lower than the theoretical COP and is found by performance experiment the laboratory.

1.2 Refrigerant

1.2.1.1 Set **R12 (CHLOROFLUOROCARBON):-** The refrigerants chlorofluorocarbon (CFCs) and Hydro chlorofluorocarbon (HCFCs) both have high ozone depleting potential (ODP) and global warming potential (GWP) and con-tributes to ozone layer depletion and global warming.

1.2.2.2 R134a (TETRAFLUROETHANE):- R134a is the long-term replacement refrigerant for R12 because of having favorable characteristics such as zero ODP, non-flammability, stability and similar vapour pressure as that of R12. The ODP of R134a is zero, but it has a relatively high global warming potential. Many studies are being carried out which are concentrating on the application of environmen-tally friendly refrigerants in refrigeration systems.

1.2.2.3 R600a (ISOBUTANE):- This work presents an study on the application of HFC134a to replace R600a in a domestic refrigerator. A refrigerator designed to work with R600a with a gross capacity experiment.R600a low pressure level is connected to a relatively high critical temperature, good Performance and Increased efficiency .Zero ozone depletion and negligible global warning potential.

Table 1: Properties of R600a, R134a & R12 used in household applications

Refrigerant	*R 600a*	*R 134a*	*R 12*
Name	Isobutene	TetraFluro -Ethane	Chlorofluorocarbon
Formula	C_4H_{10}	CH_3CH_2F	CCL_2F_2
Critical Temp°C	135	**101**	112
Molecular W in kg/k mole	58.1	102	120.9
Normal Boil point	-11.6	-26.5	-29.8
Pressure at -25 °C in bar (absolute)	0.58	1.07	1.24
Liquid density kg/lit	0.60	1.37	1.47
Vapour density kg/m^3	1.3	4.4	6.0
Volumetric capacity k J/m^3	373	658	727

1.3 Objective of the present work

The objective of the of the present work is to designed and fabricated an experimental setup when it is possible. To keep the evaporator temperature Constance, and thus the find out the COP of the unit at Constance evaporator temperature the evaporated temperature can be varied and the COP can be measured for different but constant evaporator temperature. Thus it is possible to flow a curve of COP used evaporate temperature. Detail in objective of the present work are also include to prepare to experimental setup, are perform the experimental with two different temperature using domestic refrigerator. Say R134a (Tetrafluoroethane) and R600a (Isobutene). Thus it is possible to compare the performance vapour compression refrigeration system using their two refrigerants.

2. Literature Review

1) Mihail-Dan & N. Staicovici Are investigates A method of improving the effectiveness of a mechanical vapors compression process and of its applications in refrigeration. It was shown that method can be improved of a polytrophic or an adiabatic mechanical vapors compression system.
2) Bilal Ahmed Qureshi & Syed M. Zubair, asked about all Performance decrease of a vapors compression refrigeration system under fouling conditions. In contrast to the current, from a second law, Viewpoint, the second law Efficiency. Indicates that R717 performs the best in all cases. The paper is shows that the volumetric efficiency of R410A R717 remained the highest under their respective operating condition. Performance degradation due to fouling in a simple vapour compression cycle is investigated for low, medium and high temperature applications.
3) K. Mani, V. Selladurai, Are Experimental analysis of a new refrigerant mixture as drop-in replacement for CFC12 and HFC134a are Investigate that The refrigerants chlorofluorocarbon (CFCs) and hydro chlorofluorocarbon (HCFCs) both have high ozone depleting potential (ODP) and global warming potential (GWP) and con-tributes to ozone layer depletion and global warming.
4) Akintunde, M.A.et all Experimental study of R134a, R406 and R600a blends as alternative to Freon 12. The results show that R134a/R600a mixture in the ratio 50:50 can be used as alternative to R-12 in domestic refrigerators, without the necessity of changing the compressor lubricating oil. At of Te=-5^{0}C and Tc=40^{0}C , R-12 gives a COP of 2.08 while 50:50 blend of R134a/R600a gives a COP of 2.30 under the same operating conditions.
5) According to manual of company danfoss Practical Application of Refrigerant R600a Isobutene in Domestic Refrigerator Systems is observed by Refrigerant R 600a, or isobutene, is a possible replacement for other refrigerants, which have high impact on the environment, in domestic refrigerators. It has zero ozone depletion potential ODP and a negligible global warming potential GWP.

3. Design and experimental setup

In this chapter an experimental set up is designed to find the COP of the domestic vapour compression system. The system will be of the size of a 180 L domestic refrigerator. The main objectives of the set up will be to keep the

evaporator temperature constant during the experiment on explain in the aim of the present work. In this experimental R-600a is compared with the R-134a in a domestic refrigeration system. The hermit sealed compressor, the air cool natural convection condenser and the capillary tube used for the set up are the same as for domestic refrigerator. The evaporator is placed in an insulated box which may be the use itself. The compressor is usually of 1/8 th it's a approximate 100 watt. If the overall COP of the refrigerator is assumed unity at full load. The refrigerator effect will be 100watt.In the experimental set up. The cooling load may be provided by lamp bank. The load can be varied by with15 watt, 30 watt, 45watt lamp. The vapour compression refrigeration system, so that the experimental can be carried out at different load. The watt of lamp is calculated the experiment set up as shown in fig.

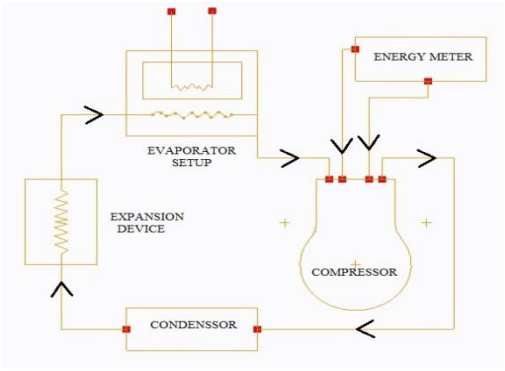


Figure 1: Design layout of Experiment setup

The experiment set up consists of following component.

1) The compressor usually sealed. The power to the compressor (watt) is measured by an energy meter disc type. And a stop watches. The thermostat is disconnected.
2) The condenser
3) The expansion device (capillary tube)
4) The evaporator
5) Lamp bank.

The evaporator lamp bank be placed is an insulated chamber the instrument.

- Pressure gauge is fit the suction and discharge of the compressor.
- Thermocouple is measured by temperature at various points.

4. Experimental Procedure

While coming comparing two types of refrigerant using in the refrigerator R134a & R600a at constant evaporator temperature. A domestic refrigerator works on vapour compression refrigeration system. The compressor, usually Hermit sealed. The power to the compressor (Kilowatt) is measured by an energy meter disc type. In this system the thermostat is disconnected because compressor is working continue. The process is comprises of a compressor, condenser, expansion and evaporator. In these processes of vapour compression refrigeration system we have utilized two type lamp banks one is three bulb in parallel connection Consuming 15 Watt each And other is two bulb in parallel connection consuming power 15 Watt each as shown in fig. Lamp bank is represented by Refrigerant effect. Because we have assume lamp bank is absolutely. The condenser is used the air cool natural convection condenser. According to first law of thermodynamic "Heat and mechanical work are mutually converted" it means that when a system is undergoes a thermodynamic cycles then the net heat supplied to the system from the surrounding is equal to net work done by system on its surrounding. A domestic refrigerator Power cable is connected by power board Switch. Type of Lamp bank is used three bulbs consuming 15 Watt each as shown in fig. So total power consume is 45 Watt. The function of evaporator to evaporate the refrigerant gains the heat three bulbs. Power board Switch ON, Domestic refrigerator compressor is start using the refrigerant R-600a (Isobutene). And then produced by cooling effect. In case, of compressor we have fixed energy to measure the power disc type energy meter at constant temperature. Take down the energy meter reading no of seconds for 5 revolution of energy meter. Take down the reading of compressor pressure discharge inlet & condenser outlet from the pressure gauges. Thermocouple is measured by temperature at condenser. Calculate coefficient of performance & energy consumption of vapors compression refrigeration system. And the experiment is repeated for refrigerant (R-134a) and the readings are measured.

5. Result and Discussion

Table: Testing R-134a using domestic refrigerator
Refrigerant effect -3*15=45 watt

Time	*Evaporator temperature ^0C*	*Energy consumed reading (Kwh)*
10:00	28.9	0.95
11:00	-15.7	1.13
12:00	-19	1.29
01:00	-21	1.45
02:00	-23	1.57
03:00	-25	1.69
04:00	-25	1.85
05:00	-25	1.99
06:00	-25	2.13

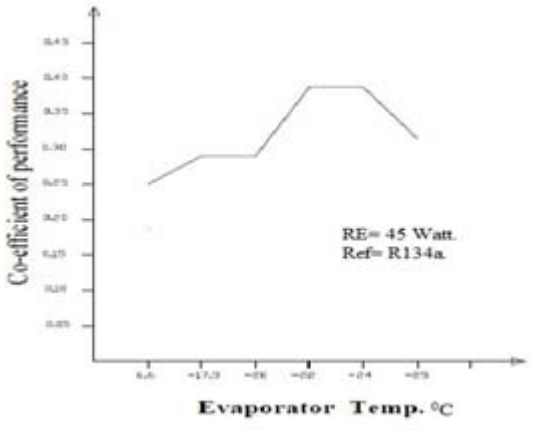
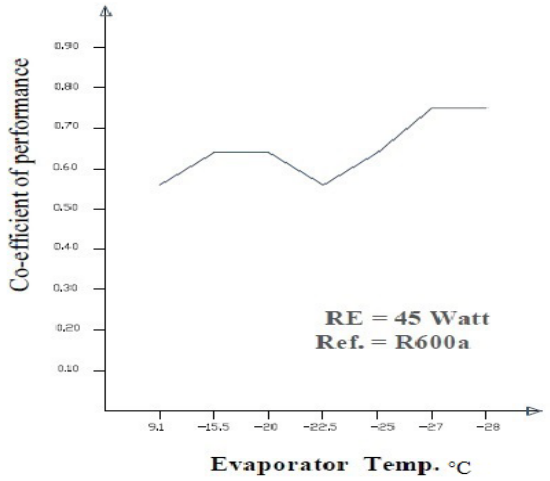


Table 8: Testing R600a using domestic refrigerator
Refrigerant effect =3*15=45 watt

Time	*Evaporator temperature*	*Energy consumed reading (Kwh)*
10:00	30.2	0.77
11:00	-12	0.85
12:00	-19	0.92
01:00	-21	0.99
02:00	-24	1.07
03:00	-26	1.14
04:00	-28	1.20
05:00	-28	1.26



Tables and figure are shows that Comparative analysis Coefficient of performance at steady state condition in domestic Refrigerator.COP Refrigerant R600a (Isobutene) is more than R134a (Tetrafluoroetane).

6. Conclusion

An experimental is calculated by comparing the coefficent of performace using refrigerant R-600a (Isobutane) and R-134 (tetrafluoraethane) at stedy state condition.

- Coefficient of performance of R600a was higher range of 40.86%-46.54% than R134a at Constance refrigerant effect 45W and Constance evaporating temperature.
- Coefficient of performance of R600a was higher range of 83.33% than R134a at Constance refrigerant effect 30W and Constance evaporating temperature.
- Refrigerating capacity of R-600a is higher than R-134a.
- The discharge temperature of compressor is decreased with 10% by using R600a compressor energy consumption refrigerator gradually decrease with 3% of compared to normal R134a domestic compressor refrigerator.
- A Domestic refrigerator with used 150 g of refrigerant R134a shows that compressor had the highest amount of energy destruction followed by the condenser, capillary tube, and evaporator.
- The optimum condition was found to be R600a charge amount 50 g compressor the lowest amount of energy destruction followed by the condenser, capillary tube, and evaporator.
- The mount of charge required for R600a is 50 g, 66%lower than R134 One.
- Energy consumption under the test condition, when tested in accordance with relevant standard as R600a is 264 unit per year and R134a is 302 units per year.

7. Scope for Future Work

- The work can be done by using the different type of fast free domestic refrigerator**.**
- Attempts can be made to reduce GWP with the same setup.
- From the review of the literature, R134a is the leading refrigerant in India which is used to substitute R12 due to its high ODP value. Even though R134a is non toxic, non-flammable and has a zero ODP, it is one of the green house gases. It is seen that most of the available alternative refrigerants are not matching with the R134a in various aspects such as saturation properties, energy efficiency and safety. On the other hand R600a has better energy efficiency but is inflammable issues, which restrict the usage in existing systems. It is possible to mix hydrocarbon refrigerants with other alternatives such as HFC refrigerants. The GWP of HFC/HC mixtures is less than one third of HFC, when it is used alone.

References

[1] D.Bulter, life after cfc_s and HCFC, CIBSE national conference 2001.
[2] S.Devotta, S.gopichand, comparative assessment of HFC 134a and some refrigerant as alternative to CFC12, International general of refrigeration 15(1992) 112-118.
[3] C.P.Arora, Third edition of refrigeration and air conditioning, Tata McGraw Hill Education Private limited New Delhi P.G. No (3-4)
[4] D.Ravindra, "Difference between_CFC/HCFC and HFC refrigerant" Air Conditioning and refrigeration journal Part-II January-February 2014.
[5] Vincenzo La Rocca, Giuseppe Panno " Experimental performance evolution of a vapour compression refrigerating plant when replacing R22 with alternative refrigerant.
[6] Mihail-Dan & N. Staicovici, International Journal of Heat and Mass Transfer, Are investigates "A method of improving the effectiveness of a mechanical vapour compression process and of its applications in refrigeration" 3 August 2010.
[7] Bilal Ahmed Qureshi, Syed M. Zubair, International Journal of Refrigeration, Performance degradation of a vapour compression refrigeration system under fouled conditions Mechanical Engineering Department, King Fahd University of Petroleum & Minerals, KFUPM Box # 1474, Dhahran 31261, Saudi Arabia.
[8] A.S. Dalkilic, S. Wong wises, International Journal of Heat and Mass Transfer, A theoretical performance study on a conventional vapour-compression refrigeration system with refrigerant mixtures supported HFC134a, HFC152a, HFC32, HC290, HC1270, HC600, and HC600a was done by various ratios and their results are comparison with CFC12, CFC22, and HFC134a as possible various replacements king mongkut university of

technology (KMUIT) Thailand, 3 August 2010.
[9] K. Mani , V. Selladurai, International journal of thermal science, An Experimental analysis of a new refrigerant mixture as drop-in replacement for CFC12 and HFC134a Refrigeration and Air-conditioning Laboratory, Coimbatore Institute of Technology, Coimbatore 641 014, India,10 January 2008.
[10] Akintunde, M.A .Mechanical Engineering department, The federal University of technology,P.M.B 704 Nigeria, Experimental study of R134a,R406 and R600a blends as alternative to Freon 12.
[11] Manual of Denfoss company Kreilaufteile fur Kalteanlagen beuth verlag, Gmbh, berlin.
[12] Alsaad, M. A., and Hammad, M. A., the Application of Propane/Butane Mixture for Domestic Refrigerators, Applied Thermal. Engineering, Vol. 18, pp. 911 918.(1998).
[13] J.S. Daniel, G.J.M. Velders, and Final Release: February From Scientific Assessment of Ozone Depletion: 2006.
[14] Jitendra Kumar Verma, Ankit Satsangi and Vishal Chaturani, IJETAE, Volume 3, Issue 1, January 2013**.** A Review of Alternative to R134a (CH3CH2F) Refrigerant.
[15] Poul Erik Hansen, Lars Snitkjmr, Michael Skovgaard and Alice Riemer, "DEVELOPMENT OF SMALL HERME11C COMPRESSORS FOR R600a" Danfoss Compressors GmbH. P.O. Box 1443. D-24939 Flensburg. Germany.
[16] W.F.Stoecker and W.F.Jones Second edition of refrigeration and air conditioning, Tata McGraw Hill Education Private limited New Delhi.

About Author

Mohd. Abuzar Qureshi was completed B E from RGPV Bhopal (M.P) in 2007. I was published few National paper in Refrigeration and air conditioning. I was antedated Thermodynamics workshop conducted by IIT Bombay (M.H) held at SVITS, Indore, Advanced Energy workshop held at IIST Indore (M.P), Reduction of ODO & GWP held at Godrej & Boyce Mfg Co. Ltd. Indore (M.P)