

Performance Evaluation of Domestic Refrigerator Using Eco-Friendly Refrigerant: A Review

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Abstract - The refrigerator is an important device in are day to day life at present 80% of domestic refrigerators are working on R-134a which is having zero ODP value but higher GWP value so there is need to find the Eco-Friendly refrigerant. The present paper is a review of one of the ecofriendly refrigerant used in the domestic refrigerator. the performance of the refrigerator will be studied using r134a refrigerant and mixture of propane R290 and isobutene R600a (50/50).then this enhanced performance due to mixture of propane R290 and isobutene R600a (50/50) will be compared with performance of refrigerator working with r134a and percentage of enhancement will be calculated on the basis of COP, refrigerating effect, power required to drive the compressor, etc..The refrigerator is also incorporated with the condenser fan and acrylic door. The performance of refrigerator using R-134a incorporated with condenser fan and acrylic door is compare with refrigerator using hydrocarbon incorporate with condenser fan and acrylic door. The comparison made between the COP, refrigerating effect, power consumption of compressor, pull down time etc

Keywords: refrigerant, condenser fan, acrylic door, COP, pull down time

1.INTRODUCTION

the refrigerating machine is a device which will either cool or maintain a body temperature below that of the surrounding. Hence, heat must be made to flow from a body at low temperature to the surrounding at high temperature. Refrigerator is an very important part in are day to day life. The refrigerator consist of thermally insulated compartment and which when work, transfer heat from inside of compartment to the external environment so that the inside of the thermally insulated compartment is cooled to the temperature below the ambient temperature. Heat rejection my occur directly to the atmosphere in case of air cooled condenser and to the water in case of water cooled condenser. The thermally insulated compartment mainly consists of condenser compressor evaporator and expansion device. The following processes are take place in the

refrigeration cycle. Heat is absorbed in the evaporator by the evaporation of the liquid refrigerant at a low pressure and corresponding low saturation temperature. The evaporated refrigerant vapour is compressed to a high pressure in the compressor consuming work W. The pressure after compression is such that the corresponding saturation temperature is higher that the temperature of the surrounding. Heat Q is then rejected in the condenser to the surrounding at high temperature.

In the late 1800s and in the early 1900 ammonia, carbon dioxide, sulphur dioxide and methyl chloride were as refrigerant. But all these refrigerant were found to be toxic and hazardous. After 1900s chlorofluorocarbons and hydro chloro fluorocarbons were used as refrigerant because they posses many suitable properties like stability, nontoxicity, non-flammable, good material compatibility etc.the main problem with CFC and HCFC is they contain chlorine which

Goes to the stratosphere where they react with ozone. As we know ozone layer protect the UV rays to fall on the earth surface so it is not good to continue the use of halogenated fluids. The CFCs have been banned in developed countries since 1996,and in 2030,producing and using CFCs will be prohibited completely in the whole world.HCFCs will be prohibited in the future. at present the household refrigerators works on refrigerant R-134a which is having low ODP(ozone depleting potential) but large value of GWP (global warming potential .many researchers are finding out the alternative refrigerant to use in refrigerators which are ecofriendly i.e refrigerant does not harm the environment and also the UV protective ozone layer. Many researchers have found that hydrocarbon is good replacement to HCFCs and CFCs.the only problem with hydrocarbon is that it is flammable.

2. LITERATURE REVIEW

Some experimental and numerical work by using ecofriendly refrigerant in domestic refrigerator has been done in the last decades. Both the industrial and academic people have taken interest in this area. The following is a review of the research that has been completed especially on refrigeration process using ecofriendly refrigerant.

M. A. Sattar, R. Saidur, and H. H. Masjuki [1], studied the effect of Pure butane, isobutene and mixture of propane, butane and isobutene in the domestic Samsung refrigerator and designed to work with R-134a refrigerant. The refrigerator's performance with no load and closed door condition has been investigated. The energy consumption of the refrigerator during experiment with hydrocarbons and R-134a was measured. The results show that the compressor consumed 3% and 2% less energy than that of HFC-134a at 28°C ambient temperature when iso-butane and butane was used as refrigerants respectively. The compressor consumes 22% and 14% more energy than that of HFC-134a when mixture 1 and mixture 2 was used as refrigerant at 28°C.

Alok Bharadwaj, et al. [2] A detailed study of thermodynamic properties of an emerging refrigerant R152a has been discussed with respect to other conventional and non-conventional refrigerants like R12, R22, R404a, R410, R134A, etc. Further, the optimum working conditions of R152a, in terms of its properties as well as design parameters, are considered and compared with other refrigerants, being used presently, in order to propose it as the most suitable and economically viable substitute to the conventional refrigerants. Lastly, solutions have been suggested to some of the problems of R152a so that it can be used as a replacement for R134a in refrigerators and ACs.

Shrikant Dhavale, et al. [3] This study focuses on an experimental study of hydrocarbon blend of isobutene (R-600a) and propane (R-290) as an environment friendly refrigerators with zero ozone depletion potential (ODP) and very low global warming potential (GWP), to replace conventional refrigerators tetrafluoro ethane R-134a in a domestic refrigerators. Comparative performance study shows refrigerating effect is improved by using hydrocarbon blends, reduction of 35-40% in the refrigerant charge, the energy consumption per day reduced by 5-10%.

Suresh Boorneni, et al. [4] The main objective in present dissertation has been focused on alternative refrigerant to conventional CFC refrigerant, CFC like R12, R22, R134a, etc... are not eco-friendly. The emission of these refrigerants causes the depletion of ozone layer etc.... Hence to avoid above difficulty the alternative of refrigerant in the form of R600a has been choosing. R600a refrigerant are natural refrigerant consist of hydrocarbon. In the present work, the performance of the domestic refrigerator is determined using R600a (Isobutane) and comparison with R134a (Tetrafluoro-ethane) as the part of project work Also in the present work an attempt has been made to improve the coefficient of performance (cop) of the system, by incorporating a heat exchanger before admitting refrigerant into the compressor. Thus the compressor work reduces and

it may results increase the performance of t M. Mohanraj, et al. [5] In the present work, an experimental investigation has been made with hydrocarbon refrigerant mixture (composed of R290 and R600a in the ratio of 45.2:54.8 by weight) as an alternative to R134a in a 200 l single evaporator domestic refrigerator. Continuous running tests were performed under different ambient temperatures (24, 28, 32, 38 and 43 °C), while cycling running (ON/OFF) tests were carried out only at 32 °C ambient temperature. The results showed that the hydrocarbon mixture has lower values of energy consumption pull down time and ON time ratio by about 11.1%, 11.6% and 13.2%, respectively, with 3.25-3.6% higher coefficient of perform

M.Y.Lee, D.Y.lee, Y.kim [6], studied the effect of mixture of R290 and R600a with mass fraction of 55 as an alternative refrigerant to R-134a in the small capacity domestic refrigerator. The compressor displacement volume of the alternative system with R290/R600a (55/45) was modified from that of the original system to match the refrigeration capacity. Both systems with R290/R600a (55/45) and R-134a were tested by varying the refrigerant charge and capillary tube length under experimental conditions for both the pull down test and the power consumption test. the capillary tube length for each evaporator in the optimized R290/R600a system were 500mm longer then those in the optimized R134a system. the power consumption of the optimized R134a system was 12.3% higher than that of the optimized R290/R600a system. the cooling speed of the optimized R290/600a(55/45) system at the in-case setting temperature of 15° C was improved by 28.8% over that of the optimized R134a system

C.C Yu and T.P ting [7] Studied the hydrocarbon refrigerant with different charge ration of 30%,40%,50%, and 60% based on the charged mass of R134a, the result of the no load pull down test revealed that the optimal charged mass for all the HC refrigerants was 40% of theta of R134a. the capillary tube length of R134a, HC1, HC2, and HC3 were recalculated to be 2.77, 5.05, 5.34, 5.6m, respectively, and the recalculated capillary tube was used in the 24-hour on load cycling test. the results of the 24-hour on-load cycling test showed that the freezer temperature considerably decreased when the HC refrigerant were used, and that all of the Hc refrigerant could be used in the R-134a refrigerator after changing the capillary tube lengths.

Rajanikant Y. Mahajan, and Sanjaykumar A. Borikar, [8] studied the Effect of refrigerant Hc-12a in the domestic refrigerator which is working on refrigerant R134a. the design temperature and pull down time set by international standard organization (ISO) for small refrigerator were achieved earlier using refrigerant HC-12a

than using R-134a. The result showed that the HC-12a have higher coefficient of performance and less energy consumption. The amount of refrigerant charge was also reduced as compared to R134a due to a higher value of latent heat of HCs.

Jwo et al. [9] used a blend of R-290 and R-600a instead of R-134a. The experiment was performed on a 440 liters domestic refrigerator. During test refrigerant R-134a was replaced with varied mass of hydrocarbon blends. The results show that refrigerating effect was improved by using hydrocarbon blends. The refrigerator which was designed to work with 150 gm of R-134a gave best result with 90 gm of hydrocarbon refrigerant that implies a reduction of 40% in refrigerant charge. The design temperature was obtained quicker when the mixture of R-290 and R-600a was used that reduced the individual working time, hence the total working time per month was lesser than by using R-134a. On average, the new refrigerant mixture offers a better refrigerating behavior and reduces the energy consumption by 4.4

Wongwises et al. [10] performed the theoretical study on traditional VCRS system with refrigerant mixture based on HFC134a, HFC152a, HFC32, HC290, HC1270, HC600 and HC600a for various ratios and their results are compared with CFC12, CFC22 and CFC134a as possible alternative replacement. Considering the comparison of coefficient of performance and pressure ratio of tested refrigerant and also the main environmental impacts of ozone layer depletion and global warming refrigerant blends of HC290(40%)+HC600a(60%) and 290(20%)+HC1270(80%) are found to be the most suitable alternatives among refrigerants tested for R12 and R22 respectively. The refrigeration efficiency, coefficient of performance of the system increases with increasing evaporating temperature for the constant condensing temperature.

Balakrishnan.P, DR.K.Karuppasamy, Ramkumar.J, Anu Nair.P [11] studied the experimental investigation of an alternative refrigerant for R-134a. The refrigerant R-134a was replaced with hydrocarbon refrigerant mixture composing of R32/R600a/R290 in the ratio 70:5:25 by weight. The performance characteristics of the domestic refrigerator were predicted using continuous running tests under different ambient temperatures and cyclic running (on/off) tests at the fixed temperature. The obtained results showed that the hydrocarbon mixture has lower values of energy consumption, pull down time and ON time ratio also higher coefficient of performance.

N.Austin, Dr.P.Senthil kumar, N.Kanthavelkumaran, [12] A household refrigerator designed to work with R-134a was used as an investigation unit to assess the prospect of using mixed refrigerants. The effect of condenser temperature and evaporator temperature on COP, refrigerating effect was investigated. The energy consumption of the refrigerator

during experiment with mixed refrigerant and R134a was measured. The outcome shows the permanent running and cycling results showed that R134a with charge of 100g or mixed refrigerant with charge of 80mg or more satisfy the required freezer air temperature of -12°C. The pull down time, pressure ratio and power consumption of mixed refrigerant refrigerator were under those of R134a refrigerator by about 7.6%, 5.5% and 4.3%, resp. Also the actual COP of mixed refrigerant refrigerator was higher than that of R134a by about 7.6%.

3. PROPOSED WORK

The aim of the present work is to evaluate experimentally, the effect of hydrocarbon (mixture of R290 and R600a) as refrigerant in the 165 liters olvins refrigerator which is design to work on refrigerant R134a. The refrigerator is also incorporated with condenser fan and acrylic door. The comparison is made between

1. coefficient of performance
2. power required to drive the compressor.
3. refrigerating effect. etc

With and without acrylic door and condenser fan

4. CONCLUSIONS:

This review has considered refrigeration process and the performance of refrigerator under influence of different refrigerants. The literature review concluded that hydrocarbon refrigerant gives good results as compared to the existing refrigerant R134a. The hydrocarbon refrigerant have low value of GWP (Global warming potential) as compared to the R134a so it does not harm the ozone layer and hydrocarbon can be consider as ecofriendly refrigerant the only problem with hydrocarbon as refrigerant is that it is flammable so precaution should be taken while charging and discharging the refrigerator with hydrocarbon

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