Review of A Domestic Refrigerator By Using R290/R600a Zeotropic Blends With R134a

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Abstract- *This investigation thermodynamically analyzes a vapour compression refrigeration system which compares R134a and R290/R600a refrigerants. The refrigerants like R12 and R22 contain chlorine atoms which are main reasons for the emission of Chlorofluorocarbon which is responsible for the ozone depletion. Hence, the alternate refrigerants like R-134a and hydrocarbon mixture (R290/R600a) are used to avoid emission of CFC. These refrigerants have zero ozone depletion potential and negligible global warming potential. The COP of the system was improved by replacing the R134a with blended Hydrocarbon R290/R600a refrigerant. In this paper, the experimental analysis of R134a and various ratios of R290/R600a refrigerants have been analyzed. In the present work performance comparison between R-134a and hydrocarbon mixture (R290/R600a) has been carried out in domestic refrigerator. Generally, the overall performance of the applied mixtures was much better than that of R134a.*

Keywords- Domestic refrigerator, Zeotropic blends, Hydrocarbons, Global warming, Ozone depletion potential

I. INTRODUCTION

Human being are looking for ways to keep their food fresh, and found out that the coldness satisfy it.Therefore the idea of refrigeration was born. For centuries people relay on ice and snow for the purpose of cooling things. Since the Roman Empire, slaves used terracotta pots fanning in water to cool down the food. That is the method of cooling by extracting heat.Until 1844, Jacob Perkins, an American inventor acquired the pattern of the first evaporative cooling refrigerator and a new chapter of refrigeration has begun. After the invention of the first refrigerator, people started to gain more and more interest in using mane-made machines rather than natural ice for cooling food. The early refrigerator models in the nineteenth century made the foundation of the more functional and more stylized refrigerators in the future.Many kinds of refrigerator exist in our society today, each with its own distinct function. But the refrigerator in our home is the most commonly seen and utilized. Many families equip with a refrigerator. No matter of its color size or layout. It serves primary function to keep our food fresh.This paper discuss specifically on home refrigerator. The working principle of a domestic refrigerator is exactly the same as that of an air conditioner. Like the air conditioner, it is also consist of the following four basic components:

i. Evaporator
ii. Compressor
iii. Condenser
iv. Expansion device

1. GLOBAL WARMING

The global warming effect is the phenomenon of increase in earth's surface temperature because of the absorption of long wave radiation by certain vapours and green house gases (John 2002). The CFCs, HCFCs and HFCs are all green house gases. Because of their molecular structure, they all have strong absorption features in the so-called window region of the infrared.The window region is the wavelength region from about 7 to 13µm, where absorption by the primary absorbers CO2 and H2O is weak (Wuebbles 1994).Global Warming Potential (GWP) has been scaled with reference to carbon dioxide, which has GWP = 1.0.

2. OZONE DEPLETION POTENTIAL

Chlorofluorocarbons, which are a family of chemical compounds derived from simple hydrocarbons (methane, ethane, etc.) by substitution atoms with halons (chlorine and fluorine), have been known and characterized since the 1890s. In 1928 Thomas Midgley projected these simple hydrocarbon derivatives as working fluids in refrigeration equipment. The CFCs posses most of the desirable characteristics, such as chemical stability, high thermodynamic efficiency, non-toxicity, nonflammability, etc. However the ozone depleting effect of CFCs is of great concern because of the harmful ultra violet radiation that might otherwise reach the surface of the earth (Rowland and Molina 1974).The CFCs and HCFCs which are stable chemicals persist for a long time in the atmosphere. They eventually break down in the stratosphere releasing chlorine or bromine, which in turn reacts with ozone (Earl 1990).The ability of a chemical to destroy ozone depends upon the halogen type (chlorine and bromine), the number of halogen atoms it releases and its residence time in

atmosphere. Each chemical has been assigned a number according to its ozone depletion potential (ODP). The reference value is ODP = 1.0 for CFC11.

3. DIFFERENT REFRIGERANTS USED IN DOMESTIC REFRIGERATOR

a)R-11 TRICHLOROMONOFLOUROMETHANE (CCL3F)

The R-11 is a synthetic chemical product which can be used as a refrigerant. It is stable, non-flammable and non-toxic. It is considered to be a low pressure refrigerant. It has a low side pressure of 0.202 bar at- 15^0C and high pressure of 1.2606 bar at 30^0C. The latent heat at-15^0C is 195 KJ/kg. The boiling point at atmospheric pressure is 23.77^0C. due to its low operating pressures, this refrigerant is exclusive used in large centrifugal compressor of 200TR and above. The leaks may be detected by using a soap solution, a halide torch or by using an electronic detector.

b) R-12 DICHLORODIFLUOROMETHANE (CCL2F2)

The R-12 is a very popular refrigerant. It is a colorless, almost odorless liquid with boiling point of -290^0C at atmospheric pressure. It is non-toxic, non-corrosive,non-irritating and non-flammable. It has a relatively low latent heat value which is an advantage in small refrigeration machines. R-12 has a pressure of 0.82 bar at -150^0C and a pressure of 6.4 bar at 300^0C. The latent heat of R-12 at -150^0C is 159KJ/kg.

c) R-134a TETRAFLOUROETHANE (C2H2F4)

The preferred replacements of R-12 can be the HFC refrigerants R-134a. This has a boiling point of -26.20^0C which bears reasonable comparison with the boiling point of R-12 (-29.80^0C). R-134 is a not a drop in replacement of R-12 because the refrigerating effect is slightly different. It does not seem to be compatible with conventional lubricants or more winding insulation. It gives higher benefits thenR-12 in using in conventional refrigerators where reasonable condensing temperature is specified. This would appear to be non-flammable and non toxic substitute for R-12 at extreme pressure ratios.

d) R290/R600a PROPANE+ISOBUTANE

It is an azeotropic mixture of propane (R290) & isobutane (R600a). It has Property very similar to R12 & R 134 which is commonly used refrigerant now a days. This blend of hydrocarbons is used in most of the AC of European cars. It contains 60% propane+40%iso butane. It is named as mint gas because it has cooling property like mint. Moreover it has zero ozone depletion potential and a reliable global warming potential (the two property due to which we need to replace the CFC's).

This blend is used for domestic refrigerator because of its following reasons-

1. Zero GWP
2. Compatible with mineral oil.
3. Pressure same as in R12 system. Almost like a drop in substitute.
4. Low discharge/winding temperatures.
5. Quantity of charge very small.
6. Easily available.

e) R-290 PROPANE (C3H8)

Propane is a three-carbon alkane, normally a gas, but compressible to a transportable liquid. A by-product of natural gas processing and petroleum refining, it is commonly used as a fuel for engines, oxy-gas torches,barbecues, portable stoves and residential central heating. A mixture of propane and butane, used mainly as vehicle fuel, is commonly known as liquefied petroleum gas (LPG or LP gas). It may also contain small amounts of propylene and or butylenes. An odorant such as ethanethiol or thiophene is added so that people can easily smell the gas in case of a leak Boiling point of propane is −187.7 ^{0}C, 85.5 K. Propane is generally stored and transported in steel cylinders as a liquid with a vapor space above the liquid. The vapor pressure in the cylinder is a function of temperature.

f) R600a ISOBUTANE (C4H10)

Isobutane, also known as *i*-butane or methylpropane, is a chemical compound with molecular formula C4H10 and is an isomer of butane. It is the simplest alkane with a tertiary carbon.Isobutane is used as a feedstock in the petrochemical industry, for example in the synthesis of isooctane.Isobutane is odorless and colourless gas.The boiling point of isobutane is -11.7 ^{0}C, melting point is -159.42^0C and vapour pressure is 204.8 kpa.

4. COMPARISON OF (PROPANE + ISO BUTENE) AND R134a

Product	R290/R600a	R134a
Chemical type	HC	HFC
Composition	Azeotropic mixture	Pure
Ozone depletion potential	0	0
Global warming potential	3	1600
Normal boiling point	−31°C	−26°C
Latent heat	367 KJ/kg	189 KJ/kg

5.CALCULATE PERFORMANCE PARAMETER OF REFREGERANTS USING SAME COMPRESSOR

Refrigerants	m×10^3	Dv	COP
R134a	0.5973	0.608	1.91
R290/R600a	0.3462	0.612	1.70

6. THERMODYNAMIC PROPERTY OF R290/R600A

Temperatures	Pressure	Enthalpy (liquid)	Enthalpy (vapour)	Entropy (liquid)	Entropy (vapour)
°C	Bar	KJ/kg	KJ/kg	KJ/kg	KJ/kg
-30	1.14	130.6	529.5	0.732	2.404
-25	1.67	153.1	542.3	0.823	2.387
-20	2.01	164.6	548.6	0.868	2.381
-10	2.39	176.6	555.0	0.912	2.35
-5	2.82	188.1	561.3	0.956	2.371
0	3.31	200	567.7	1.00	2.367
5	3.85	212.1	574.0	1.044	2.365
10	4.47	224.4	580.0	1.087	2.362
15	5.15	236.8	586.4	1.130	2.361
20	5.91	249.5	592.6	1.173	2.359
25	6.75	262.3	598.6	1.216	2.359
30	7.67	275.3	604.6	1.259	2.360
35	8.67	288.5	610.5	1.301	2.360

7. THERMODYNAMIC PROPERTIES OF REFRIGERANT

Properties	Unit	R600a	R290/R600a	R290
Chemical name		Isobutene	Isobutene+propane	Propane
Molecular mass	Kmol/kg	58.1	51	44.1
N.B.P	°C	-11.7	-31.7	-42.1
Critical temperature	°C	135.0	105.5	69.7
Critical pressure	Bar	36.45	34.01	42.48

8. CALCULATE PERFORMANCE PARAMETER OF REFREGERANTS USING SAME COMPRESSOR

Refrigerants	m×10^3	Dv	COP
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R290/R600a	0.3462	0.612	1.70

9. THE FLAMMABILITY LIMITS ARE APPROX. AS

Refrigerant	R600a	R290
Lower flammability limit (LFL)	1.5% by vol. (38g/m³)	2.1% by vol. (39 g/m³)
Upper flammability limit (UFL)	8.5% by vol. (203 g/m³)	9.5% by vol. (177 g/m³)
Ignition temperature	460°C	470°C

II. LITERARURE SURVEY

Barathiraja. K: From their Experiment, the Coefficient of Performance of the Blended Hydrocarbon R290/R600a mixtures is high when compared with the R134a refrigerant. The Power consumption of the Hydrocarbon refrigerant R290/R600a has been decreased as compared to the R134a. The coefficient of performance has increases while time increases due to suction of high pressure and temperature increases. The Compressor work has been increased by using the mixture of R290/R600a hydrocarbon than that of R134a.Hydrocarbon R290/R600a mixture has higher refrigerant effects than R134a due to higher latent heat values. R134a has higher GWP. Hence permanent solution is necessary. (R290/R600a) with zero ODP and negligible GWP. Hence R600a has been be used as an alternative refrigerant.

Shrikant Dhavale: This study focuses on an experimental study of hydrocarbon blend of isobutane (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 tetrafluoroethane R-134a in a domestic

refrigerators. The performance is observed for a domestic refrigerator by using blend of hydrocarbon R- 600a and R-290 and its performance is compared with R-134a without change in original system. Due to the higher value of latent heat of hydrocarbons the amount of refrigerant charge required found to be reduced as compared with hydrofluorocarbon R-134a. Comparative performance study shows refrigerating effect is improved by using hydrocarbon blends, reduction of 40% in the refrigerant charge, the energy consumption per day reduced by 5%.COP of R600a and R290 (50/50) is found to be increased at all conditions compared with R134a.At full load 40lit average COP increments is found to be 4.6 Hydrocarbons blends may replace R-134a without any system modifications and COP of the system is improved with reduced energy consumption. So our future intension is that increase the requirement of HC-as a refrigerant in all types of domestic refrigerators and air conditioning system in near future. Due to the zero ozone depletion potential (ODP) and negligible global warming potential (GWP), environments becomes a safe and sweets. In develop countries HC as a refrigerant use in car air conditioning as well as industrial air conditioning.

Neeraj Agrawal: System performance of an existed 134a domestic refrigerator with propane/isobutene (50/50%) zeotropic blend is measured as a drop-in substitute. An in-house experimentations test facility was developed. The experiments are conducted under various charge condition to find optimum charge. Experiments were conducted at constant load condition. The optimum charge is measured as 60 g with R290/R600a (50/50%) zeotropic blend and the lowest temperature is recorded as -3.5°C. It can be concluded that R290/R600a (50/50%) zeotropic blend can be a good option as a replacement of R134a. However, the flammability aspect of the hydrocarbons needs to be addressed.

Abinesh.T K.Karuppasamy: The problem of R134a refrigerant is identified from the environmental site. An alternativerefrigerant is chosen with better COP and is compared with R134a. The mass flow rate and COP of the chosen refrigerant is calculated and is compared with R134a. Mass concentration ratio is (70/25/5) mixer time that COP and Mass flow rate calculated. Condensation temperature is fixed (32^0C) and evaporator temperature is also fixed (-5^0C) that time calculated COP and Mass flow rate. R134a at unloading ON condition time, the COP and mass flow rate were lower than (R152a/R290/R600a). Using (R152a/R290/R600a) at loading ON condition time, the COP and mass flow rate values are higher than R134a. The (R152a/R290/R600a) is starting cooling process lower than R134a. Mixing refrigerants GWP (global warming potential) is lower than R134a.

Ajoy Bhargav: The paper deals with the energy analysis of mixture and of propane and iso butane with R12 and R134a.The cycle considered for study is having super heated vapour after compression. Efforts have been made to consider super cooling also.In the above study comparison of mint gas is done with R-12 and R-134 for in domestic refrigerators. From the observation we found that mint gas can be an option which could produce better results. Al though its implementation requires a detail experimental calculations. Mint gas is providing more COP then ordinary refrigerants another advantage of this refrigerant was that it does not react with compressor oil. The only disadvantage associated with this gas is its flammability, which can be an obstacle in its implementation.This problem can be solved by proper design of the refrigerator.

III. CONCLUSION

In the study of comparison of R290/R600a zeotropic blends with R134a in the domestic refrigerator exhibits higher COP. Global warming potential of zeotropic blends is less. These refrigerants mixture have superior heat rejection – better condenser heat exchange performance. Operates at lower pressures to R134a.These refrigerants mixture reduced load on compressor, less heat at compressor and less power drain when running. Faster pull down temperature and Lower temperatures at all times. The disadvantage associated with zeotropic blends is flammability, which is only obstacle in implementation.

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