IJAET International Journal of Application of Engineering and Technology ISSN: 2395-3594

Vol-2 No.-3

Comparative Analysis of R290/R600a with commonly used refrigerant

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ABSTRACT

A domestic refrigerator designed to work with R134 a was investigated to assess the possibility of using a mixture of propane and iso butane. The performance of the refrigerator using azotropic mixture as refrigerant was investigated and compared with the performance of refrigerator when R134a, R12, R22, R290, R600a is used as refrigerant. The effect of condenser temperature and evaporation temperature on COP, refrigerating effect, condenser duty, work of compression and Heat Rejection Ratio where investigated. The energy consumption and COP of hydrocarbons and there blends shows that hydrocarbons can be used as refrigerant in the domestic refrigerator 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.

Keywords: *- Global warming, ozone depletion potential, refrigerants, coefficient of performance, specific power, domestic refrigerator*

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:

- Evaporator
- Compressor
- Condenser
- Expansion device

II. 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.

III. 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

ISSN 2395-3594

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, non-flammability, 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.

IV. DIFFERENT REFRIGERANTS USED IN DOMESTIC REFRIGERATOR

a) R-11TRICHLOROMONOFLOUROMETHANE (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□C and high pressure of 1.2606 bar at 30□C. The latent heat at-15□C is 195 KJ/kg. The boiling point at atmospheric pressure is 23.77□C. 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 -29^0C 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 -15^0C and a pressure of 6.4 bar at 30^0c. The latent heat of R-12 at -15^0c 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 -26.2^0C which bears reasonable comparison with the boiling point of R-12 (-29.8^0C). 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) PROPANE+ISOBUTANE

It is an azeotropic mixture of propane (R290) & iso butane (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 refrigerators 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

ISSN 2395-3594

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 °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.

V. COMPARISON OF (PROPANE + ISO BUTENE) WITH R12 AND R134A

Product	R290/R600a	R12	R134a
Chemical type	HC	CFC	HFC
Composition	Azeotropic mixture	Pure	Pure
Ozone depletion potential	0	0.9	0
Global warming potential	3	10600	1600
Normal boiling point	-31^0c	-30^0c	-26^0c
Latent heat	367 kJ/kg	145 kJ/kg	189 kJ/kg

VI. THERMODYNAMIC PROPERTY OF R290/R600A

Temperatures	**pressure**	**Enthalpy (liquid)**	**Enthalpy (vapour)**	**Entropy (liquid)**	**Entropy (vapour)**
^{0}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	2.375
-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	580.2	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

VII. THERMODYNAMIC PROPERTIES OF REFRIGERANT

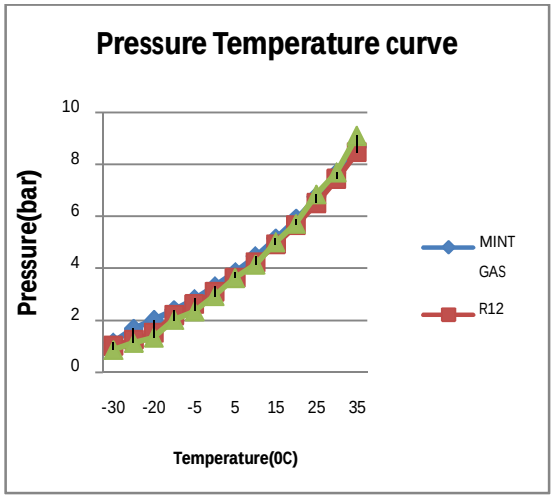
Properties	**Unit**	**R-600a**	**R290/R600a**	**R-290**
Chemical name		Iso butene	Isobuten e + propane	prop ane
Molecular mass	Kmol /kg	58.1	51	44.1
N.B.P	^{0}c	-11.7	-31.7	-42.1
Critical temperature	^{0}c	135.0	105.5	69.7
Critical pressure	Bar	36.45	34.01	42.48

VIII. TYPICAL USES OF REFRIGERANTS BEFORE 1987

Typical application	**Refrigerants recommended**
Domestic refrigerators and freezers	R12
Small retail and supermarkets	R12, R22, R502
Air-conditioning	R11, R114, R12, R22
Industrial	R717, R22, R502, R13B1
Transport	R12, R502

IX. CALCULATED PERFORMANCE PARAMETERS OF R12 AND NEW PROPOSED REFRIGERANTS USING SAME COMPRESSOR AS IN R12 REFRIGERATOR

Refrigerants	$m\times10^3$	η_v	COP
R12	0.8	0.772	1.84
R134a	0.5973	0.608	1.91
R290/R600a	0.3462	0.612	1.70



ISSN 2395-3594

FIG.1 Pressure Temperature Curve

X. CONCLUSIONS

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.

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ISSN 2395-3594