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Comparative analysis of mint gas with R-12 and R-134 refrigerants

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Abstract-Today, environment safety has become an important aspect of the industries and people in common. The global warming, climate change ozone layer depletion and many other environmental disasters have prompted a need to look for environmental friendly operations and process for fulfilling our basic and other needs such as transportation, production of materials etc. This paper aims at development of one such eco friendly system for domestic refrigerators. The commonly used domestic refrigerators use the gas which either deplete the ozone layer or contribute in the global warming in the same as CO2 does. This work consists of using a hydrocarbon gas mixture known as mint gas which does not deplete ozone layer, is eco friendly, and can be used in the commonly used refrigerators without any significant change in the system. Efforts have been made to include various aspects to get the maximum knowledge about the refrigerant. Refrigerant physical and chemical properties of different refrigerants are included in this paper. This paper summarizes analysis of refrigerant used in domestic refrigerator with the mint gas. It present tabulated global warming potential and other environmental data for different refrigerants. This paper also discuses on the C.O.P (coefficient of performance).

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

1-Introduction

Human being are looking for ways to keep their food fresh, and found out coldness can satisfy. 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 refrigerators

Home refrigerators are a home at low appliance, usually closet shape container with doors used to store food and reduce food bacteria growth by using vapor compression cooling. Vapor compression

A typical home refrigerator consists of these five basic parts- Compressor

- Condenser
- Expansion valve
- Evaporator

1.1 Global Warming-

The phenomena of green house effect are essential to maintain the temperature of earth. But human activities which are continuously

changing the concentration of atmosphere increasing amount of heat trapping gases and thus earth's temperature. This effect is known as global warming.

1.2 OzoneDepletionPotential-(CFCs) chlorofluorocarbons and other halogenated ozone depleting substances (ODS) are mainly responsible for man-made chemical ozone depletion. The total amount of effective halogens in the stratosphere can be calculated and are known as the (EESC) equivalent effective stratospheric chlorine.

1.3 Different refrigerants used in domestic refrigerator

R-11 Trichloromonoflouromethane (CCL_3F)

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.

R-12 Dichlorodifluoromethane (CCL_2F_2)

The R-12 is a very popular refrigerant. It is a colorless, almost odorless liquid with boiling point of -29°C 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°C and a pressure of 6.4 bar at 30°c. The latent heat of R-12 at -15°c is 159KJ/kg.

R-134a Tetraflouroethane ($C_2H_2F_4$)

The preferred replacements of R-12 can be the HFC refrigerants R-134a. This has a boiling point of -26.2°C which bears reasonable comparison with the boiling point of R-12 (-29.8°C). 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.

MINTGAS (PROPANE+ISOBUTANE)

Mint gas 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 contain 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 negliable 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-

- Operates at similar pressure to R-12 & R-134.
- Posses similar volumetric refrigerating effect to R-12 and R-134a.
- Can be used in a R-12 or R-134a compressor.
- Can be used with R-12 or R-134a heat exchangers and expansion devices.
- Compatible with most common refrigeration materials and lubricants.

R-290 Propane (C_3H_8)

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 butylene. 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.

1.4 Comparison of mint gas with R-12 and R-134a

Product	Mint gas	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	-31c	-30c	-26c
Latent heat	367 KJ/Kg	145 KJ/kg	189 KJ/kg

1.6Thermodynamic property of mint gas-

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	1.39	141.8	535.9	0.778	2.395
-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

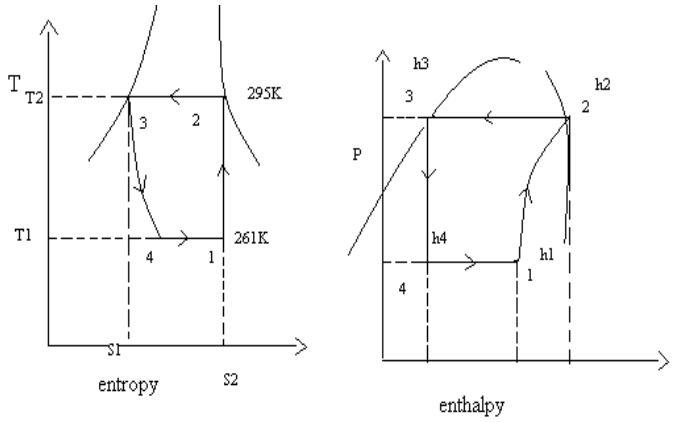
1.5Comparison physical and chemical properties-

Properties	Unit	R-600a	Mint Gas	R-290
Chemical name		Isobutene	Isobutene + propane	propane
Molecular mass	Kmol /kg	58.1	51.0	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

1.7 Theoretical observation showing that (C.O.P) of mint gas is higher then cop of R-134a

Case study

Taking the case of dry saturated vapors after compression in VCR system



Taking R-134 in above case

Saturation temperature	Pressure Bar	Enthalpy (liquid) KJ/kg	Enthalpy (vapours) KJ/kg	Entropy (liquid) KJ/kg	Entropy (vapours) KJ/kg
295K	5.91	151.96	293.29	0.554	1.0332
261K	1.39	56.32	322.58	0.226	1.2464

C.O.P from the above- 4.36

Taking Mint Gas in above case

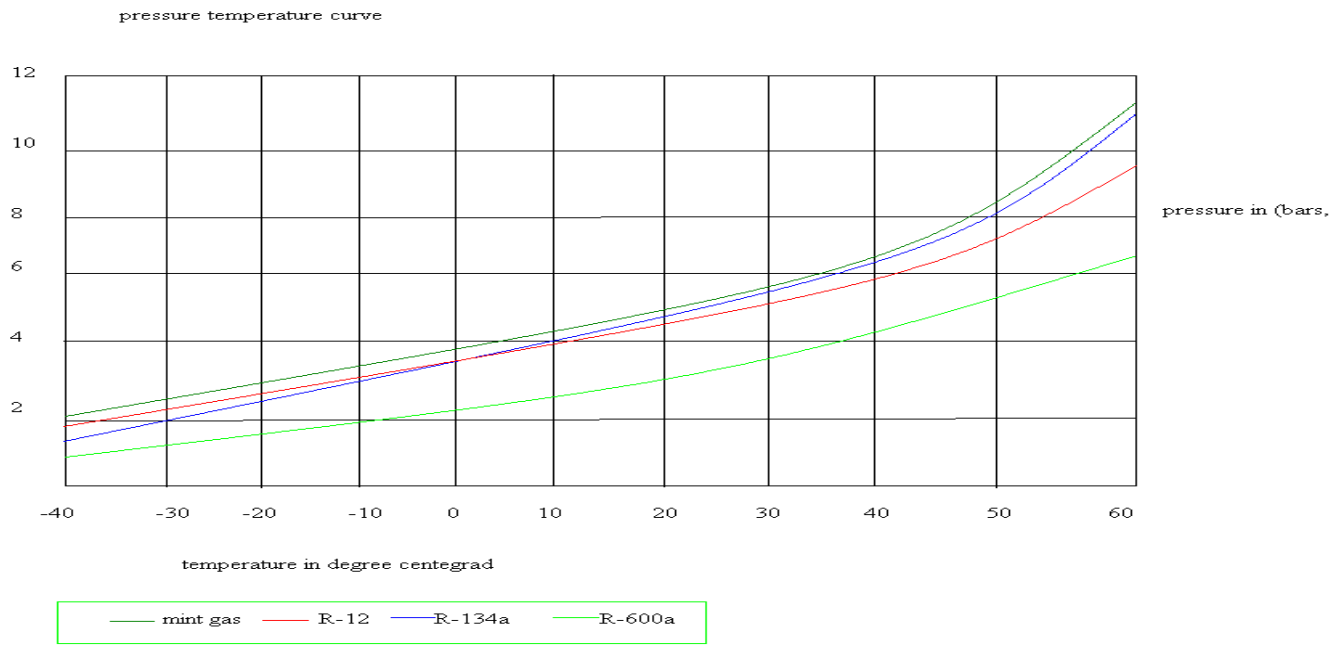
Saturation temperature	Pressure Bar	Enthalpy (liquid) KJ/kg	Enthalpy (vapours) KJ/kg	Entropy (liquid) KJ/kg	Entropy (vapours) KJ/kg
295K	5.91	255.9	595.6	1.515	2.3605
261K	1.39	170.45	551.8	0.8005	2.391

C.O.P from the above-5.15

1 .8C.O.P of different refrigerants –

Refrigerants	COP (kW/kW)	Specific power (kW/ton)
R-11	6.58	0.53
R-12	6.29	0.56
R-22	6.18	0.57
R-32	5.97	0.59
R-113	6.52	0.54
R-114	6.34	0.56
R-123	6.52	0.54
R-124	6.31	0.56
R-125	5.68	0.62
R-134a	6.24	0.56
R-141b	6.58	0.54
R-152a	6.35	0.55
R-227ea	6.04	0.58
R-236fa	6.26	0.56
R-290 (propane)	6.14	0.57
R-600 (n-butane)	6.42	0.55
R-600a (isobutane)	6.34	0.56

1.9 PRESSURE TEMPERATURE CURVE-



1.10Conclusions-

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.

1.11 References

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