International Journal of Engineering Sciences Paradigms and Researches (IJESPR)
Vol. 48, Special Issue, (TAME-2019, April 4-5, 2019)
(An Indexed, Referred and Impact Factor Journal approved by UGC- Journal No. 42581)
ISSN (Online): 2319-6564
www.ijesonline.com

ALTERNATIVE REFRIGERANTS WITH LOW GWP & ODP FOR COMMERCIAL AND DOMESTIC PURPOSE: A REVIEW

[1]Mohani, [2]Ravindra Ram,[3]Sachin Jambhale [4]Sanjeev Kumar
[1]MGMCoET, Noida (U.P), India,
[1]mohani@coet.in

[2]MGMCoET, Noida (U.P), India,
[2]ravindra@coet.in

[3]MGMCoET, Noida (U.P), India,
[3]srjambhale@gmail.com

[4]YMCA University of Science and Technology, Faridabad, India,
getsan25@rediffmail.com
*Corresponding Author: mohani@rediffmail.com

Abstract

Refrigeration is a process for maintaining a temperature below the surrounding temperature. Tetrafluroethane R134 is commonly used as a refrigerant in domestic refrigeration after 2000, before that halogenated refrigerants R12 were used in refrigeration which responsible for ozone layer depletion which act as armour for preventing us from ultraviolet radiation. Refrigerant R134a has zero ozone layer depletion (OLD) but higher rate of global warming potential (GWP) and after Kyoto protocol global warming is serious issue as it increases the overall temperature of our surroundings and then arising the need of alternate refrigerants that can be used in place of refrigerant R134a (Tetrafluroethane) in domestic refrigerator. In this paper, study has been done on the alternative refrigerant for replacing the traditional refrigerant R134a. Various researchers working for the find an alternative refrigerant with higher coefficient of performance and cooling effect. Many researchers investigated the blend of propane and isobutane (R290 & R600a) which is a pure hydrocarbon refrigerant which have the almost same thermodynamic physical properties as of Tetrafluoroethane refrigerants. In this paper reviewed the various research works for selecting the blend of refrigerant, acceptable thermo-physical properties, blend in various proportion and operating parameters.

Keywords: *Alternative refrigerants, Global warming potential, Ozone layer depletion and thermo-physical properties.*

1. INTRODUCTION

Out of all refrigeration systems, the vapour compression system is the most important system from the view point of commercial and domesticutility. It is the most practical form of refrigeration. In this system the working fluid is a vapour. It readily evaporates and condenses or changes alternately between the vapour and liquid phases without leaving the refrigerating plant. During evaporation, it absorbs heat from the cold body. This heat is used as its latent heat for converting it from the liquid to vapour. In condensing or cooling or liquefying, it rejects heat to external body, thus creating a cooling effect in the working fluid. This refrigeration system thus acts as a latent heat pump since it pumps its latent heat from the cold body or brine and rejects it or delivers it to the external medium.

The following fundamental processes in a simple vapour compression system are completed in one cycle as given below:

- i Expansion
- ii Evaporation
- iii Compression
- iv Condensation

2. REFRIGERANTS

A 'refrigerant' is defined as any substance that absorbs heat during the evaporation process from the medium to be maintained at the required temperature and loses it through condensation to the cooling medium in a refrigeration system. The natural ice and a mixture of ice and salt were the first refrigerants. The term 'refrigerant' in the broadest sense is also applied to secondary cooling mediums as cold water or brine, solutions. Those working mediums which pass through the cycle of evaporation, recovery, compression, condensation and liquefaction, is usually refrigerants. The rejection of heat results as the cost of some mechanical work. In the early day's only , the refrigerants, Air, ammonia (NH3), Carbon dioxide

(CO_2), Sulphur dioxide (SO_2), possessing chemical, physical and thermodynamic properties permitting their efficient application and service were used in the practical design of refrigeration equipment .The refrigerants change its state from the liquid to vapour in complete cycle of refrigeration.

2.1CLASSIFICATION OF REFRIGERANTS

The refrigerants are classified as follows:

- Primary refrigerants.
- Secondary refrigerants.

2.1.1Primary Refrigerants

Those working mediums or heat carriers which directly take part in the refrigeration system is termed as primary refrigerants and is maintained the temperature of the substance by the absorption of latent heat e.g. halo-carbon refrigerants , azeotrope group , inorganic group and hydro-carbon refrigerants such as Ammonia, Carbon dioxide, Sulphur dioxide, Methyl chloride, Methylene chloride, Ethyl chloride.

2.1.2 Secondary Refrigerants

The refrigerants which are first cooled by the primary refrigerants and then employed for cooling purposes , are known as secondary refrigerants, e.g. calcium chloride ($CaCl_2$) , sodium chloride i.e. common salts and ethylene glycol , propylene glycol etc. The refrigeration will occur by the absorption of sensible heat. The primary refrigerants are listed as follows: Now a day commonly used refrigerant R11 & R12 are to be replaced because of their long term greenhouse effects R502, R134a & R410a is already used in many medium sized refrigeration installations to replace R22, which has much lower O_3 depleting potential then either R11 or R12 and is seen as a transitional substance which can be used during next 30 years or more until a suitable refrigerants can be developed.Vapour compression refrigeration cycle is a very widely used cycle of refrigeration in ground, air, space and marine applications. It uses a variety of refrigeration such as ammonia (NH_3), Freon group(R-12, R-22, etc), Sulphur dioxide (SO_2) and Carbon dioxide (CO_2).

CFCs-CFCs, composed of carbon, chlorine, and fluorine, became a popular type of refrigerant beginning in the 1930s because they were viewed as an attractive non-toxic, non-flammablealternative to the dangerous incumbent refrigerants, such as methyl chloride and sulphur dioxide. However, CFCs were phased out in the 1990s because they posed enormous risk to the earth's ozone layer. Common CFCs included R11, R12, R113, R114, and R115. Though no longer in production or in widespread use, a few legacy systems and appliances still operate using CFCs. Table 1 provides the reduction timeline for CFCs in the U.S.

Table 1. Reduction Timeline for CFCs in the U.S.

Year	Percent reduction in consumption and production from 1989 baseline
1991	15%
1992	20%
1993	25%
1994	75%
1995	75%
1996	100%

HCFCs- HCFCs have a structure very similar to CFCs, but with the addition of hydrogen. Because they share many of the physical properties of CFCs but are less damaging to the ozone layer, HCFCs were the most common replacement for CFCs in the 1990s and 2000s. However, HCFCs do still pose some risk to the ozone layer, and like CFCs, HCFCs are potent greenhouse gases. For this reason, HCFCs are in the process of being phased out, with 99.5 percent reductions slated to happen by 2020. Common HCFCs include R123 and R22. Indeed, R22 has possibly been the most widely used refrigerant in recent times, as it was ubiquitous in residential appliances, refrigeration systems, and automobile air conditioning systems for many years. Though R22 is no longer used in new equipment, a significant amount of the refrigerant is still operating in legacy systems. Table 2 provides the reduction timeline for HCFCs in the U.S.

HFCs-As HCFCs have been phased out, HFCs, which contain hydrogen, fluorine, and carbon, have been the primary replacement. Not similar to CFCs and HCFCs, HFCs create no damage to the ozone layer because HFCs lack the chlorine atom that is responsible for the reaction that destroys ozone molecules. However, like CFCs and HCFCs, HFCs are greenhouse gases. As a result, HFCs have also been targeted for phase down (though not a total phase out) by international treaty.

3. REFRIGERANT PHASE OUT TIMELINES

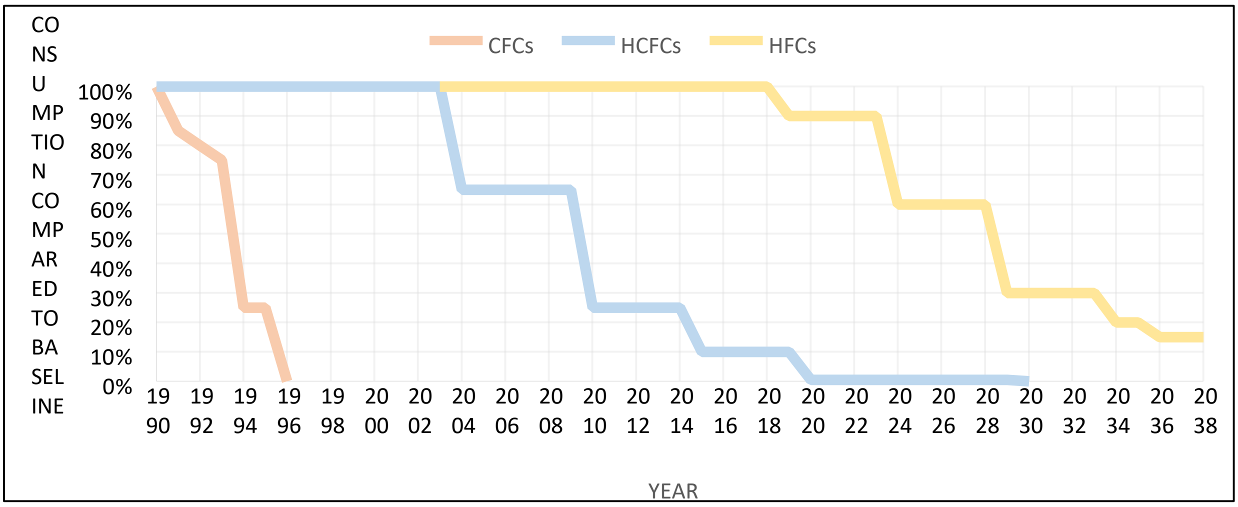

Fig.1Refrigeration phase out timelines

4. ENVIRONMENTAL IMPACTS OF REFRIGERANTS

There are two important metrics to look at when evaluating the impacts of a refrigerant on the atmosphere. The first is GWP, which tells us how powerfully a particular refrigerant acts as a greenhouse gas. The other metric is ozone depletion potential, or ODP, which quantifies the amount of damage a given refrigerant causes to the ozone layer.

4.1 GWP

To cleanly compare the global warming threat of refrigerants, GWP evaluates these compounds over a theoretical 25- or 100-year atmospheric lifetime. This is essentially a measure of how much one ton of agas will contribute to global warming over that 25- or 100-year span, relative to the emissions of one ton of CO2. A 25- or 100-year GWP provides a common unit of measure, which allows us to add up emissions estimates of different gases and compare emissions reduction opportunities across sectors and gases.

4.2 ODP

Like 25- or 100-year GWP, ODP is a unit less measurement. ODP compares the lifetime ozone destructive potential of different substances; with CFC-11 serving as the baseline (CFC-11 has an ODP value of 1). All CFCs have an ODP somewhat close to 1, while HCFCs tend to be somewhat to significantly lower. ODP values scale linearly, meaning that a substance with an ODP of 0.5 causes, on average, half the ozone layer destruction as a substance with an ODP of 1.

Table 2.List of Refrigerant with GWP and ODP

Refrigerant	ODP	Atmospheric lifetime (Years)	GWP (100 Year)	Notes
CFC-11	1	50	400	
CFC-12	1	102	8,500	
CFC-112	0.8	85	5,000	
CFC-114	1	300	9,300	
CFC-115	0.6	1700	7,300	
HCFC-22	0.55	13.3	1,700	
HCFC-123	0.02	1.4	93	
HCFC-124	0.022	5.9	480	
HCFC-141b	0.11	9.4	630	
HCFC-142b	0.065	19.5	2,000	

HCFC-225c/a	0.025	2.5	170	
HFC-23	0	270	14,800	
HFC-32	0	5.6	650	
HFC-125	0	32.6	2,800	
HFC-134a	0	14.6	1,430	
HFC-143a	0	48.3	3,800	
HFC-152a	0	1.5	140	
HFC-404a	0	40.4	3,260	Refrigerant blend
HFC-407c	0	15.7	1,530	Refrigerant blend
HFC-410a	0	17	1,730	Refrigerant blend
HFC-434a	0	30	3,245	Refrigerant blend
HFC-437a	0	17	1,805	Refrigerant blend
HFC-507a	0	40.5	3,300	Refrigerant blend
HFO-1234yf	0	0.029	1	
HFO-1234ze	0	0.045	1	
HFO-1336mzz	0	0.06	2	
R-170	0	12	6	Ethane
R-290	0	12	4	Propane
R-600	0	12	5	Butane
R-600a	0	12	5	Isobutane
R-601	0	12	11	Pentane
R-717	0	0.03	0	Ammonia
R-744	0	100	1	CO_2

5. ADVANCED REFRIGERATION SYSTEM DESIGNS

With a smaller HFC refrigerant charge, Advanced systems tend to operate than a traditional centralized DX system in range of 50% to 80%; these systems also often use a non-fluorinated refrigerant such as it include the following:

5.1 Propane (R-290)

It is used in stand-alone systems; such as, Ben & Jerry's has placed more than 4,500 propane ice cream freezer cabinets across the United States. The multiple propane are used in some supermarkets stand-alone units in lieu of a multiplex rack system to cool their maximum refrigerated cases and walk-in coolers and freezers; in 2013, H-E-B at Mueller became the first supermarket in the United.

5.2 Ammonia (R-717)

In industrial refrigeration systems, Proven refrigerant, now entering the commercial refrigeration market. Multiplex rack systems , Ammonia-based often use a cascade design with CO2; in this system, to condense CO2, ammonia is used which is then passed throughout the store to cool the refrigerated cases.

5.3 Carbon Dioxide (CO2, R-744)

By max. Number of beverage companies (e.g., Coca-Cola, PepsiCo) use it to replace HFC-134a in vending machines. This is used In multiplex rack systems, most commonly used in form of the heat transfer fluid in secondary loop systems or in the low-temperature loop of cascade systems.

5.4 HFO/HFC Blends

New refrigerant mix (e.g., with HFCs and HFOs) with lower GWPs, such as R-449B, R-450A , R-448A, R-449A, , and R-513A, has became admissible for application in commercial refrigeration applications under SNAP in 2014 and 2015. It began in 2014 for use; market demand is expected to increase in the next few years.

6. Future Outlook

The alternative chemicals and new technologies can reduce HFC significantly used in both the near and long term. The maximum industries adopt these chemicals and technologies, and some challenges lay ahead, the commercial industry of refrigeration are working on new developing alternative refrigerants. In future, it is expected that many new commercial refrigeration systems sold in the U.S.

market will contain lower-GWP alternative refrigerants.

7.CONCLUSION

Study of literature of alternative refrigerant carried out a lot of information about the environment friendly, selection of the refrigerants for blend, various different weight proportions of refrigerants in blend and thermo-physical properties and performance and efficiency of refrigerants and refrigeration systems. The following conclusion is drawn from previous research observations:

- The refrigerant R134 have a high global warming potential while the alternative refrigerant blend of refrigerants have low global warming potential with zero ozone layer depletion factor and also not produces toxic and hazardous effect on environment.
- Blend of refrigerants R290/R600a were used in refrigeration system when power consumption and cooling speed were 12.3% lower than the R134a and improved 28.8% over the R134a because R290/R600a have relatively high heat transfer performance and slightly higher operating pressure.
- The refrigerator worked efficiently when mixed refrigerant was used as refrigerant instead of R134a. The experimental observation of the previous research works the successful use of this mixed refrigerant as an alternative to R134a in domestic refrigerators.

8. REFERENCES

[1] Ahmet selim dalkilic (2010) "Yildiz Technical University Mechanical Engineering Faulty Department of Mechanical Engineering.

[2] Development of Statistical Models for Predicting Performance of R12, R134a and R290/R600 Mixture Refrigerants using Design of Experiments; K. Mani and V. Selladurai, N. Murugan; International Journal of Thermodynamics(IJoT) Vol. 16 (No. 1), pp. 43-53, 2013 ISSN 1301-9724 / e-ISSN 2146-1511.

[3] Experimental Study of Hydro-Carbon blend to Replace R-134a in a Domestic Refrigerator with Testing and Training of ANN; N. Austin Dr. P. Senthil Kumar Dr. P. M. Diaz; INDIAN JOURNAL OF APPLIED RESEARCH Volume : 3 | Issue : 4 | April 2013 | ISSN - 2249-555X.

[4] K. Mani (2008) "Practical analysis of a new refrigerant blend as drop-in replacement for CFC12 and HFC134a" Coimbatore Institute of Technology, Coimbatore, India.

[5] M. Mohanraj (2008) "Experimental investigation of R290/R600a mixture as an alternative to R134a in a domestic refrigerator" National *Institute of Technology.*

[6] Manohar Prasad (2009) "Refrigeration and Air-Conditioning" Indian Edition TMH.

[7] Mukesh K. Agrawal, Dr. Ashok G. Matani, (2012) "Evaluation of vapour compression refrigeration system using different refrigerants a review"

[8] S. Subramani, M. J. Prakash (2011) "Experimental studies on a vapour compression system using nanorefrigerants"

[9] Wilbert F Stoecker/ Jerold W. Jones (2008), Refrigeration and Air-Conditioning, International Edition TM.