ISSN (Online) 2456-1290

International Journal of Engineering Research in Mechanical and Civil Engineering (IJERMCE)

Vol 9, Issue 5, May 2022

Future Trends of Eco-Friendly Refrigerant in the World

[1] Anshul, [2] Ashutosh Singh, [3] Aman Kumar Verma, [4] Vikrant Mishra

[1] [2] [3] [4] Department of Mechanical Engineering, Rajkiya Engineering College Mainpuri, AKTU Mainpuri, India.
Corresponding Author Email: [1] anshul902753@gmail.com, [2] ashutosh894853@gmail.com, [3] aman.kverma210@gmail.com, [4] mishra92vikrant@gmail.com

Abstract*— This paper presents a study on environmental friendly refrigerant with negligible global warming potential and zero ozone layer depletion as compare to other conventional refrigerant. Conventional refrigerant like- CFC and HCFC and other toxic and flammable gases have to be replaced by the eco-friendly refrigerant in the way of protecting our atmosphere. In the study we got eco-friendly refrigerant is acceptable replacement of conventional refrigerant with good COP (coefficient of performance) increment 15% approx. They have 4.5% less energy consumption as compare to conventional refrigerant. They also achieved good refrigeration temperature.

***Index Terms*— Eco-friendly refrigerant, Ozone layer depletion, Global warming, Energy, COP**

I. INTRODUCTION

In this Modern world, Refrigeration process plays an important role in domestic as well as in industrial purposes. At this time cannot imagine life without the Refrigeration. A report published in the mint in august2018 “according to NFHS data one in three Indian have their own refrigerator and a fifth have their own AC”. According to UNEP OzonAction 3 billion of refrigerator, Air-conditioning and Heat Pump used in the world and the total population of the world is 7.9 billion. Refrigeration is a dominating industry in the world with the help of this industry 12 million people got employment. In the COVID -19 pandemic we show role of refrigeration is either to store vaccine or blood, maintain the temperature of the room. Refrigeration consumes 450 kWh electricity annually almost 14% of total electricity. Cooling industry produce 10% CO2 emission worldwide that is three times of the aeronautics and maritime transport. That increases the temperature of world and also the demand of refrigeration increase continuously.

A. Evaluation of the refrigerant used in the Refrigeration

Evaluation of the refrigerant used in the Refrigeration

In the starting of refrigeration, we use refrigerant like- ammonia, Sulphur dioxide, methyl chloride and propane in 1800s. Scientists found [6] that these refrigerants are highly toxic and flammable in the nature that causes the accident when they leaked. So, they tried to found non- toxic and non-flammable refrigerant and the research end when Thomson Midgley create first non- toxic and non – flammable refrigerant R-12(Freon) in 1928. In that time these refrigerant like- CFC, HCFC and HFC are very popular and demanding in the market. Era of CFC and HCFC end when the scientists discover that the HCFC and CFC damage the ozone layer that saves earth from ultraviolet radiation in 1980s. These refrigerants have good global warming potential so the many of authority in the world take strict action against the use of CFC and HCFC. In the list of restrictions first United States environment protection agency restrict the sale of refrigerant under the clean Air act in 1994. After that many countries take strict action against the CFC and HCFC refrigerant. Germany makes a decision in which they declared use of CFC refrigerator illegal in 1995.

In 1996 European start a mission to find natural refrigerant and they establish many companies and institute.

In 1996 European start a mission to find natural refrigerant and they establish many companies and institute.

In 1996 European start a mission to find natural refrigerant and they establish many companies and institute.

B. Requirements of phase evaluation in refrigerant

Phase 1- when the scientists found the refrigerant are toxic and flammable that cause the incidents.

Phase 2 - when the scientists found the refrigerant deplete ozone layer and global warming cause.

C. Property of good refrigerant

- High critical pressure
- More dielectric strength
- High latent heat of vaporization
- More heat transfer coefficient
- Non toxic
- Non flammable
- Low water solubility
- Non-reactive
- Leakage detection
- No ozone layer depletion
- Low global warming potential

ISSN (Online) 2456-1290

International Journal of Engineering Research in Mechanical and Civil Engineering (IJERMCE)

Vol 9, Issue 5, May 2022

Table – 1 Refrigerant's properties

Refrigerant		Toxicity In (ppm)	Flammable	Global warming potential	Ozone layer depletion
Ammonia		25	B2L	0	0
Sulphur dioxide		5	B1		
Methyl chloride		100	B2	13	0.02
CFCs	R-11	1000	A1	4660	1
	R-12	1000	A1	10200	1
	R-13	1000	A1	13900	1
	R-115	1000	A1	7670	0.44
HCFCs	R-22	1000	A1	1760	0.055
	R-31	320	B2		0.02
	R-114	1000	A1	8590	1
	R-142b	1000	A2	2310	0.07
HFCs	R-32	1000	A2L	677	0
	R-404a	1000	A1	3992	0
	R-410a	1000	A1	2088	0
	R-134a	1000	A1	1300	0
R-290		1000	A3	9.5-3.3	< 0
R-600a		1000	A3	6-2	< 0
R-510a		1000	A3	1.24	< 0
R-744		5000	A1	1	0

- More toxic< 400ppm
- Less toxic > 400ppm

Table–2 Flammable properties

A3 ,B3	Highly flammable
A2 ,A2L ,B2 ,B2L	Low flammable
A1,B1	Non flammable

D. Some eco-friendly refrigerants

Hydrocarbon- In the present time hydrocarbons play an important role in the refrigeration. Hydrocarbon are the compound of hydrogen and carbon atom. Hydrocarbon are natural, non-toxic. Hydrocarbon highly flammable and explosive in nature. They also have low global warming potential and no ozone layer depletion. Hydrocarbons like-propane, butane, isobutene [4] are commonly used as a refrigerant in the vapour compression and absorption refrigerant system. Pressure and temperature of hydrocarbons is similar to HCFCs and CFCs. Hydrocarbon have similar properties to HCFCs and CFCs so it replaces them after the 1980 as a refrigerant. When we use hydrocarbon as a refrigerant in place of fluorocarbon then find 50% more effective. Hydrocarbon operate at lower pressure that save 17% to 54% energy. Hydrocarbons are cheapest at small scale but at large scale it need explosion proof shielding that increase the cost of plant.

Ammonia- A mixture of nitrogen and hydrogen gas at 450℃ - 500℃ at 200 atmospheric pressure in the presence of iron catalyst ammonia is produce. Ammonia also found naturally in the tissue of organic body. When the body decompose it release ammonia. Ammonia is a colorless and piquant smell gas which have lower density than air. Ammonia present in the form of gas and its boiling temperature is -33.34℃ at 1 atmospheric pressure. Ammonia also found throughout the solar system. In the ammonia nitrogen and hydrogen strong [5] bonding it liquefied easily. In the last 1800 ammonia use as a refrigerant because it is easily mixed with the water that provide wide range of temperature variations. Ammonia is a toxic gas but we use ammonia at high risk as a refrigerant because ammonia has low global warming potential, no ozone layer depletion and archives low refrigeration temperature. It is more efficient than the CFC. Ammonia use in the vapour compression and absorption refrigeration system. Due to its toxicity and corrosiveness it is very important for the safety purposes to use in closed system and material is corrosion resistant. It is available in large amount on the earth so it cost is low as compare to many other refrigerants. Ammonia use in the big and commercial plants as a replacement of CFCs and HCFCs.

Water- Water present on earth before the starting of living things on the earth. On earth 71% of water cover the earth out of 71%, 97% of water present in the oceans. Water is an organic, transparent, tasteless, odorless and colorless substance. Water has no global [7] warming potential and no ozone layer depletion. Water is an oldest refrigerant that we use in the refrigeration process because of its availability and natural property. Boiling and freezing point of water are 100℃ and 0℃ respectively. we do not use water frequently due to its high boiling and frizzing point that not allow to achieve low temperature.

Co_2 – Co_2 is a natural gas present in the atmosphere. Amount of Co_2 increase after the industrial revolution from 280 part per million to 412 part per million. In the atmosphere volume of Co_2 is 0.04%. Natural source of Co_2 is volcanoes, forest fires and hot springs. Co_2 has good heat transfer coefficient, relatively insensitive to pressure losses and very low viscosity. Co_2 has no ozone layer depletion. Co_2 is a colorless gas and odorless at low concentration and at high concentration its order change in acidic. Liquid and solid co_2 are play an important role in the many industries for the refrigeration purposes. Solid co_2 called as "dry ice" which used in the transportation when the refrigeration required and work space compact in size. Dry ice always below the -78.5℃ at 1 atmospheric pressure. Co_2 work as a refrigerant in the sub-critical, trans-critical cycle because it high condenser pressure. At high volumetric capacity co_2 is used because co_2 operate up to 130 bar so it required high mechanical resistant reservoirs and component that also required in mass production. The coefficient of performance of the Co_2 based more depend on the surrounding and appliance's use. Co_2 also use in heating purposes.

ISSN (Online) 2456-1290

International Journal of Engineering Research in Mechanical and Civil Engineering (IJERMCE)

Vol 9, Issue 5, May 2022

Table-3 Difference between HCFC, CFC and HFC

	HCFC	CFC	HFC
Ozone depletion	Medium	High	Low
components	Hydrogen and chlorine	No hydrogen atoms	No chlorine atoms
Order	Sweetish	order less	order less
Persistence	Medium	High	Low
Boiling temperature	Low	Medium	High

II. LITERATURE REVIEWS

1-Dhrumil Patel, Jign Dave and Jainil Thakkar- They experimentally evaluate different environments friendly refrigerant in 1Ton windows AC. They had developed a prototype model that specifically contain only those parts which are available and in use regularly. In this project they use R-1234yt refrigerant in the windows AC as an alternative of R-22 and R-23 refrigerant using in windows AC. R-22 and R-23 refrigerant are highly flammable and high global warming potential which is 1700 and 675 respectively. They found that the saturation pressure of R-1234ze is significantly lower that the R-134a, [1] which means that the cycle will operate lower the atmospheric pressure. They also investigate the mass flow rate of compressor reduce due to this required to redesign new compressor.

2-Bolaji B.O. - In the study, they find the way of selecting of environmental friendly refrigerant which have low global warming potential and zero ozone layer depletion. They also discussed about the environmental problems that is arises due to the composition of halocarbon. In the selection of suitable eco-friendly refrigerant, they use methane and ethane derivatives. The trade-offs and consideration refrigerant without chloride contain in [3] the bottom row of matrix triangles of methane and ethane derivatives. The eco-friendly refrigerant from methane derivatives is R-23 or R-32 and from ethane derivatives are R-125a, R-143a, and R-134a R-125. They also said that the research on this refrigerant focus continuously till the end of worldwide acceptance.

3-Samira Benhadid Dib and Ahmed Benzaoui – In the study, they worked on worth of reorganize these eco-friendly refrigerants as an alternate option to replace CFC and HCFC. They try to produce refrigerant which have no chloride and no fluorine components and not release any CO_2 in the atmosphere. To protect our environment, they have used this project. They being too produced storage and cooling facilities to food safety and seeds, shielding pharmaceuticals and cooling of pharmacy and also air quality. They also work on minimizing of greenhouse gases and replacing of contaminating refrigerant.

4- Vijayan Gurumurthy Iyar and Nikos E Mastorakis- They worked on the elimination of greenhouse effect and ozone layer depletion by enlargement of suitable eco-friendly refrigerant and air conditioning system. The observation of this experiment regarding performance of d refrigerator when composition of - propane, butane, isobutene is used as a possible alternate of R-12 refrigerant. They made four hydrocarbon mixtures of propane, butane, isobutene.

Table-4 compositions of hydrocarbons-

Hydrocarbons	Composition (%) 1	Composition (%) 2	Composition (%) 3	Composition (%) 4
Propane	100	75	50	25
Butane	Nil	19.1	38.3	57.5
Isobutene	Nil	5.9	11.7	17.5

They found that the mixture 3 is the most suitable refrigerant alternative. Mixture achieves -16°c evaporator temperature with 3.7 coefficients of performance at constant temperature of 27°c as compared to 3.6 coefficient of performance for the R-12 refrigerant in the same refrigerator. When the refrigerant worked more than 5000 hours there is no degradation of [2] lubrication oil. The refrigerator used in a long period of time they do not find any problem in different component of refrigerator.

5- S.O. Banjo, B.O. Bolaji, I.O. Sagie, O.S.I. Fayomi, O.B. Fakehinde, P.S Olayiwola, S.O. Oyesdepo, N.E. Udoye- They worked on performance characteristics of an eco-friendly HC-600a as a refrigerating refrigerant in a thermal system. In order to improvement in the performance of refrigeration system they use 46g of isobutene and 70g of conventional refrigerant HCF-134a and found that the cop of the system increased by 32.2% and energy reduction of 4.5% HC-600a obtained refrigeration temperature of -21°c in 60 minutes whereas HFC134a obtained the equal refrigeration temperature in 2 hours 15 minutes.

III. CURRENT SENARIO OF REFRIGERANTS IN INDIA

India has 10% incensement in electricity consumptions from the year 2000. In India 2015 – 2016 second highest consumption of electricity recorded but at that time electricity consumption in air-conditioning sector share is 7-9% which is increase up to 15% in year 2018-2020. With the energy consumption increase emission of by product also increase that increase the global warming potential. India introduces low-global warming potential mechanisms to achieve energy efficiency in the air- refrigeration sector.

A. Heating, Ventilation and Air-Conditioning segment

In India heating, ventilation and air-conditioning device take a major portion of the electricity consumption in residential, commercial and industrial applications. In India room air-conditioning consume 50% of total share. After that central plant dominant in the share with 24%. According to

ISSN (Online) 2456-1290

International Journal of Engineering Research in Mechanical and Civil Engineering (IJERMCE)

Vol 9, Issue 5, May 2022

compound annual growth rate demand of room air conditioning increase 12% in last five years. Annual demand in the 2021 of room air conditioning is 6 million units. Most of room air conditioning is 1 ton capacity.

B. India cooling action plan

On March 8, 2019, Ministry of Environment, Forest and Climate Change released India cooling action plan to address the India cooling demand and challenges through a holistic approach.

India cooling plan focus on reducing the cooling demand and improve the efficiency of the cooling components by applies new technology. India cooling plane consider the short, medium, and long term recommendation to provide cooling and heating comfortable to all sector and launch various program and schemes have mainly focus on maintain and enhance the energy efficiency and phase down the HFCs.

After the implementation of Kigali amendment the usage of R22 has decrease from 50% in 2016 to 38% in 2017, R410a has decreased from 41% to 36% and share of R32 increase from 8% to 17%. This show the phase down of HFCs. India will complete the HFCs phase out in four steps First start from the year 2032 with 10% reduction in use of HFCs, 20% reduction in year 2037, 30% reduction in year 2042 and 80% reduction in year 2047.

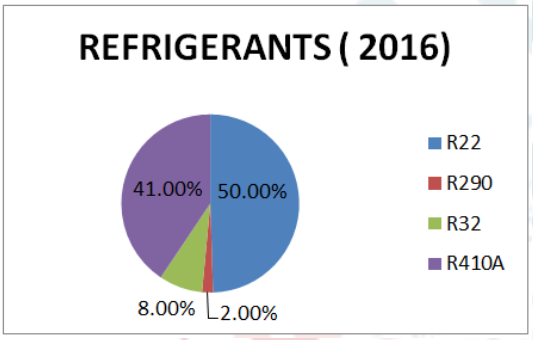

Chart 1- Refrigerants used in 2016

In this scenario, Kigali amendment impacts the demand of refrigerants. HCFCs are phase out till 2030 and the demand of low global warming potential is 10,000 metric tons. Demands of HFCs have to decrease 25% till the year 2030 and demand of low global warming refrigerant increase faster.

IV. CONCLUSION

In the current scenario we used some eco-friendly refrigerant like- HFCs (R-404a, R-134a and R-410a) in residential air conditioning system R-32 or R-600a in car air conditioning system, R-1234yf and CO2 in trading refrigeration they have no ozone layer depletion and low global warming potential. Eco-friendly refrigerant chemical reaction present in the atmosphere so they do damage the atmosphere as compare to HFCs and HCFCs and CFCs. We can say that the upcoming refrigerant era is the eco-friendly refrigerants. But we have many other refrigeration systems that worked on the CFC and HCFC nowadays so if we need to replace the old one refrigerator with the new one continuously. If we replace all the refrigerator till 2030 then we save 450Twh to 413Twh energy consumption. According to demand till 2030 apparatus requirements increases up to 62% so we need eco-friendly refrigerant to overcome the energy crisis. Every year approximately 8 million hydrocarbon based refrigerator produce in Europe.

REFERENCES

[1] Dhrumil Patel, Jign Dave, Jainil Thakkar, “Experimentally evaluate different environment friendly refrigerant in 1 Ton window AC” IRJET Volume: 08 Issue: 01, January 2021.

[2] Bolaji, B.O., “Selection of environmental-friendly refrigerants and the current alternatives in vapour compression refrigeration systems” Journal of science and management Volume:01 No:01, August 2011.

[3] Samira Benhadid-Dib, Ahmed Benzaoui “Refrigerants and their environmental impact Substitution of hydro-chlorofluorocarbon HCFC and HFC hydro-fluorocarbon. Search for an adequate refrigerant” ELSEVIER Energy Procedia Volume: 18 pp: 807-816, 2012

[4] Vijayan Gurumurthy Iyer and Nikos E Mastorakis “Experimental investigations on Eco-Friendly refrigeration and air conditioning systems” 4th WSEAS FMA pp: 445-450, 21-23 August 2006.

[5] S.O. Banjo, B.O. Bolaji, I. Osagie, O.S.I. Fayomi, O.B. Fakehinde, P.S. Olayiwola, S.O. Oyedepo, N.E. Udoye, “Experimental analysis of the performance characteristic of an eco-friendly HC600a as a retrofitting refrigerant in a thermal system” Journal of physics: Conference Series Volume: 1378 No: 04 article no.: 042033, December 2019.

[6] Dr. Claus Barthel Thomas Götz “The overall worldwide saving potential from domestic refrigerators and freezers” BigEE report, December 2012.

[7] Manjeet Singh, Gurprasad Gurumurty, Shreya Shekhar, Karan Mangotra “Mapping the Refrigerant Trends in India: An Assessment of Room AC sector” The Energy and Resources Institute, march 2019. 20 p.