Efficient Refrigerant for VARS by Thermodynamics Analysis: A Review

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Abstract

Refrigeration and air conditioning are essential applications nowadays. It has a wide range of applications in domestic and industrial VARS, VCRs & VADRS systems that are used nowadays. VARS system is an eco-friendly refrigeration system, and it has a wide range of refrigerants for working. In this paper, we reviewed the most essential 15 refrigerants, studied their thermal characteristics, and tried to find out the best suitable, eco-friendly, nonflammable, and suitable for the VARS system.

Keywords: - *Refrigerants, Thermal Properties, Characteristics, Ideal Refrigerant for VARS*

INTRODUCTION

The epidemic demand for cooling is a major consideration for future energy acknowledgement, aggravated by increased living standards in developing and emerging-market regions.

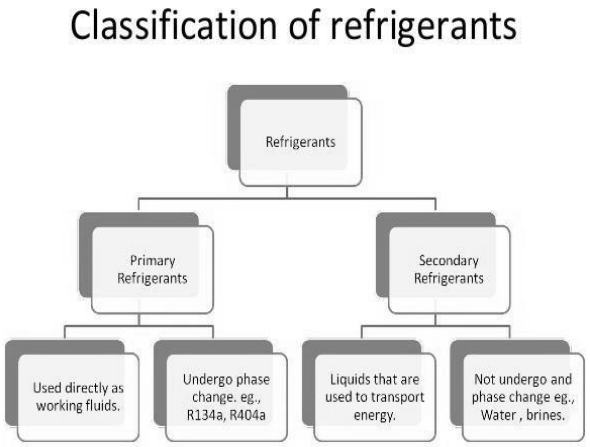
Refrigeration is an old technology that started a long time ago. Before introducing mechanical refrigeration systems, people cooled their food with ice transported from the mountains, and ice was stored using snow cellars. These pits were dug into the ground and insulated with wood and straw. After time passed, technology takes a firm stand towards development in the individual sector. By almost 2030, it is expected that energy consumption for space cooling will be doubled, with more than 80% of the growth occurring in non-organisation for economic and development countries. Refrigeration is the process of removing heat from an enclosed space or a substance to maintain a lower temperature than the surroundings. Before 1830, food preservation methods like salting, spicing, smoking, pickling and drying existed.

Evaporative cooling was practised in India and Egypt. Absorption-refrigeration cycles differ from vapour-compression cycles in the way that the refrigerant is returned from a vapour to a liquid phase. The vapour is absorbed into a second fluid component (an absorbent) with a higher boiling point in absorption cycles, omitting a compressor's requirement. However, most absorption-refrigeration systems require a small amount of electrical energy to drive a circulation pump.

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REFRIGERANT

Refrigerants are the working medium used in refrigerating systems that evaporate by taking the heat from the space to be cooled, thus producing the cooling effect. Refrigerant development will occur throughout history for different reasons, such as safety, stability, reliability, economic or environmental issues, and properties. Thus, giving rise to new research and equipment improvement in terms of safety and efficiency. The classification of refrigerants given below shows how we can classify them.



PROPERTIES OF REFRIGERANT

Theoretically, any fluid presents a potential for refrigeration, but the fluids should show some fundamental properties as actual refrigerants. Such as are followed, the refrigerants should have a low boiling point and low freezing point.

The refrigerants should be nominated mainly for their high latent heat of vapourisation.

A. They must be harmless: non-toxic, nonflammable, non-explosive and non-corrosive.
B. The pressures of the refrigerants should allow their use in a refrigeration system with a reasonable size of the pipes and compressor.
C. They must have high miscibility with lubricating oil.
D. It has to be a good density.
E. Finally, the most important criteria in the present-day world are that the refrigerant should have zero ozone layer depletion potential and very low global warming potential.

Sr. No	Refrigerant	Chemical Name	Boiling Point At *C	Vapour Pressure At 0*F	Density At G/Cm^3	Flammable Limit In Air
1	Ammonia	Nh3	-28	16 Psi	0.88	16.25 %
2	Chlorofluorocarbon	Cfc	-30	84.9 Psi	1.49	Not Flammable
3	Hydrochlorofluorocarbon	Hcfc	-40.7	17.4 Psi	1.49	Not Flammable
4	Carbon-Dioxide	C02	-55.6	20 Psi	1.62	12-75 %
5	Tetrafluroethane	C2f4	-55.8	19 Psi	1.32	4-10 %
6	Hydrofluorocarbon	Hfc	-50.8	14.7 Psi	1.02	Not Flammable
7	Halocarbon	C2f6	-26.3	39 Psi	1.39	6-10 %
8	Diclorofluromethan	C2h2cif	-29.8	45 Psi	1.33	5-17 %
9	Azeotrope	Cs2	-45.4	5 Psi	0.789	Not Flammable
10	Hydrocarbon	Hc	-0.32	12 Psi	0.42	8-12 %
11	Sulfur-Dioxide	S02	-47.8	11 Psi	1.46	Not Flammable
12	Propane	C3h8	-11.7	14.7 Psi	0.493	2-9.5 %
13	Isobutane	C4h10	-40.2	13 Psi	1.23	1.8-9.6 %
14	Helium	He	-38.2	12.8 Psi	0.138	Not Flammable
15	Zeotropic		-88.8	2 Psi	0.952	Not Flammable

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HISTORY OF REFRIGERANTS

A) AMMONIA:-

Ammonia was first used as a refrigerant in the 1850s in France and was applied in the United States in the 1860s for artificial ice production. The first patents for ammonia refrigeration machines were filed in the 1870s. By the 1920s, ammonia refrigeration was being applied to ice rinks.

Advantages:

Ammonia is the most environmentally friendly refrigerant. It belongs to the group of so-called "natural" refrigerants, and it has both GWP (Global Warming Potential) and ODP (Ozone Depletion Potential) equal to zero.

Disadvantages:

1. The major disadvantage of ammonia as a refrigerant is its toxicity.
2. Due to ammonia's hygroscopic nature, it migrates to moist areas of the body, including the eyes, nose, throat and moist skin and may cause severe burn injuries.
3. Ammonia vapours are a fire and explosion hazard at concentrations between 16% and 25%.

Application:

1. Based refrigeration systems include thermal storage systems.
2. HVAC chillers, process cooling, air conditioning, winter sports, district based refrigeration systems include

B) CHLOROFLUROCARBON:

In 1928, two inventors, Thomas Midgley, Jr. and Charles Franking Kettering, invented Freon. This refrigerant was made with a few types of chlorofluorocarbons or CFCs. Freons are colourless, nonflammable, has no odour and offer a non-corrosive gas or liquid.

Advantages:

1. CFC's hold several advantages over ammonia, as they are unreactive and non-toxic molecules,
2. Readily liquefied upon compression.
3. Their boiling point and high dependence on pressure made them idea working fluids.

Disadvantages:

1. Depleting the ozone layer from CFCs creates dangerous environmental effects and increases exposure to dangerous ultraviolet rays, which can cause: Cataracts. Weakened immune system. Skin cancer.

Application:

1. refrigeration cycle
2. industrial equipment

C) HYDROCHLOROFLUOROCARBON:-

Chlorofluorocarbons (CFCs) and hydro chlorofluorocarbons (HCFCs) were developed in the US in the early 20th century and became widely used as refrigerants and for making plastic foams producing refrigerators and freezers until the early 1990s, when it was found that these chlorinated gases damaged the ozone layer

Advantages:

1. It reduces the emission of ozone-depleting substances, which will protect the ozonelayer.
2. It will save energy and reduce greenhouse gas emissions.

Disadvantages:

1. High toxicity.

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Application:

1. Refrigeration, air conditioning, foam blowing, solvents, aerosols, and fire suppression.

D) CARBON DIOXIDE:

Some might be surprised by the idea of replacing HCFCs and HFCs with known greenhouse gas, but in reality, it has been utilised in heating and cooling equipment since the 19th century.

CO2 was first patented as a refrigerant in Great Britain in 1850. By 1869, an American, Thaddeus S.C

Advantages:

1. CO2 has very low global warming potential compared with conventional HFC systems, which significantly reduces direct emissions.
2. Indirect emissions are also much reduced as the system efficiency is much greater than achieved using conventional HFC refrigeration.

Disadvantages:

1. The main problem of carbon dioxide as a refrigerant is its inherent high working pressure.
2. This pressure is much higher than that of the other natural and synthetic refrigerants mentioned.

Application:

1. CO2 can only be used in the classic and very efficient refrigeration cycle when heat discharge temperatures are lower than the critical temperature (e.g., when used in the lower stage of a cascade system, with another refrigerant being used in the higher stage)

G) TETRAFLUROETHANE:

1,1,1,2-Tetrafluoroethane first appeared in the early 1990s to replace dichlorodifluoromethane (R-12), which has ozone-depleting properties.

Advantages:

1. It is now being used to replace R-12 CFC refrigerant in centrifugal, rotary screw, scroll and reciprocating compressors.
2. It is safe for everyday handling as it is non-toxic, nonflammable and non-corrosive.

Disadvantages:

1. Tetrafluoroethylene with flames or hot surfaces over 250 °C (482 °F) may cause vapour decomposition
2. The emission of toxic gases including hydrogen fluoride and carbonyl fluoride. However, the decomposition temperature has been reported as above 370 °C.

Application:

1. Domestic refrigeration and automated parts.

H) HYDROFLUOROCARBON:-

HFCs were developed as alternatives to ozone-depleting substances that are being phased out under the Montreal Protocol.

Inappropriately, HFCs have a global warming potential of 1000 to 3000 times that of CO2, and their use had increased from almost nothing in 1990 to 1,100 million tons of CO2e in 2010.

Advantages:

1. HFCs are relatively nonflammable, chemically stable, and nonreactive.
2. Many are colourless, odourless gasses, but some—such as HFC-365mfc (1,1,1,3,3-perfluorobutane)— are liquid at room temperature.

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3. As refrigerants, HFCs are used in various cooling systems, from refrigerators and freezers to automotive air-conditioning units.

Disadvantages:

1. What they do harm, however, is the ozone layer.
2. HFCs are a greenhouse gas, and so emitting them contribute to global warming.
3. While in volume, their emission rate is much lower than other gases, they're thought to affect over a hundred times worse than carbon dioxide.

Application:

1. R-134a. R-134ais a hydro fluorocarbon (HFC) designed for domestic, commercial.
2. Industrial refrigeration systems, air conditioning systems, liquid refrigeration systems and heat pumps.

I) HALOCARBON:-

Halocarbons are a family of manufactured molecules consisting of hydrogen, carbon, fluorine, chlorine, and bromine. The history of halocarbons, sometimes known as CFCs and Halons, is tied to the development of refrigeration. In this room, there was a refrigeration system driven byammonia.

Advantages:

1. There is no air and moisture infiltration in these halocarbon systems.
2. Ammonia systems tend to be better maintained than halocarbon systems because leaks around the valve stem, compressor shaft seals, and other leak-prone devices announce themselves due to the pungent odour – even at very low concentrations.

Disadvantages:

1. The major and the most unfortunate disadvantage is that this "self- alarming" nature of ammonia also entices injury litigation should a refrigerant leak occur. On the other hand, the halocarbons are nearly odourless, and leaks tend to go unnoticed by anyone outside of the maintenance group.

Application:

1. food preservation,
2. industrial equipment, refrigeration systems

J) DICLOROFLUROMETHAN:-

Chlorodifluoromethane or difluoromonochlor methane is hydro chlorofluorocarbon HCFC. This colourless gas is better known as HCFC- 22, or R-22, or CHClF. It is commonly used as a propellant and refrigerant. These applications are being phased out in developed countries due to the compound's ozone depletion potential (ODP) and high global warming potential (GWP). However, international use of R-22 remains to increase because of high demand in developing countries. R-22 is a versatile intermediate in industrial organouranium chemistry, e.g. as a precursor to tetrafluoroethylene.

Advantages:

1. A refrigerant is a substance or mixture, regularly a fluid, used in a heat pump and refrigeration to halogenated refrigerants, hydrocarbons like isobutane (R-600a) and propane (R- 290) offer several advantages: low cost and widely available

Application:

1. R134a is an extremely the common refrigerant used in a wide range of refrigeration and air

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conditioning applications, including medium and high temperature.

K) ZEOTROPIC:-

A zeotropic mixture, or else a non-azeotropic mixture, is a mixture with components that have different boiling points. For example, nitrogen, methane, ethane, propane, and isobutane constitute an azeotropic mixture. Individual substances within the cross do not evaporate or condense at the same temperature as one substance. In other words, the combination has a temperature glide, as the phase change occurs in a temperature range of about four to seven degrees Celsius rather than at a constant temperature. This temperature glide can be seen as the temperature difference between the bubble and dew point on temperature-composition graphs. For zeotropic mixtures, the temperatures on the bubble (boiling) curve are between the separate component's boiling temperatures. When an azeotropic mixture is boiled or condensed, the composition of the liquid and the vapour changes according to the mixture's temperature-composition diagram.

Advantages:

1. High energy transport
2. High efficacy

Disadvantages:

1. Special equipment requirement.
2. Corrosion happens.

Application:

1. Refrigeration systems.
2. Air conditioning.
3. Food preservation.

L) HYDROCARBON:-

Halocarbons are a household of industrial molecules consisting of hydrogen, carbon, fluorine, chlorine, and bromine. The history of halocarbons, sometimes known as CFCs and Halons, is tied to the development of refrigeration. In this room, there was a refrigeration system driven by ammonia.

Advantages:

1) High co-efficient of performance.

Disadvantages:

1. Consume more material.
2. Overall costing go high

Application:

1. Refrigeration system
2. Industrial equipment.
3. Automated parts.

M) SULFUR DIOXIDE:-

It is produced from burning fossil fuels (coal and oil) and the smelting of mineral ores (aluminium, copper, zinc, lead, and iron) that comprehend Sulphur.

Sulphur dioxide liquefies easily in water to form sulfuric acid.

Advantages:

1. Low concentration
2. Easily available.

Disadvantage:

1. High toxicity.
2. High ODP

N) PROPANE:-

R290 (Propane) is refrigerant mark propane, used as an alternative to R404A and R407 series refrigerants in new refrigeration and air conditioning systems. R290 (Propane) is a Hydrocarbon, and though highly flammable, it is an efficient refrigerant with a low Global Warming Potential (GWP).

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Advantages:

1. Low climate effect.
2. Easily available
3. Good thermal properties.

Disadvantages:

1. Serious safety concerns in an enclosed system.

M) ISOBUTANE:-

Refrigerant. Isobutane is used as a refrigerant. Its use in refrigerators started in 1993 when Greenpeace presented the Green freeze project with the German company Ferron.

Advantages:

1. Low climate impact.

Disadvantages:

1. Very dangerous for health and safety.

Application:-

1. Commercial refrigeration and industrial pipeline.

N) HELIUM:-

It is a colourless, odourless, tasteless, non-toxic, inert, monatomic gas, the first in the noble gas group in the periodic table.

Its boiling point is the lowest among all the elements. Helium is the second lightest and most copious element in the observable universe (hydrogen is the lightest and most abundant).

Advantages:

1. High co-efficient of performance.

Disadvantages:

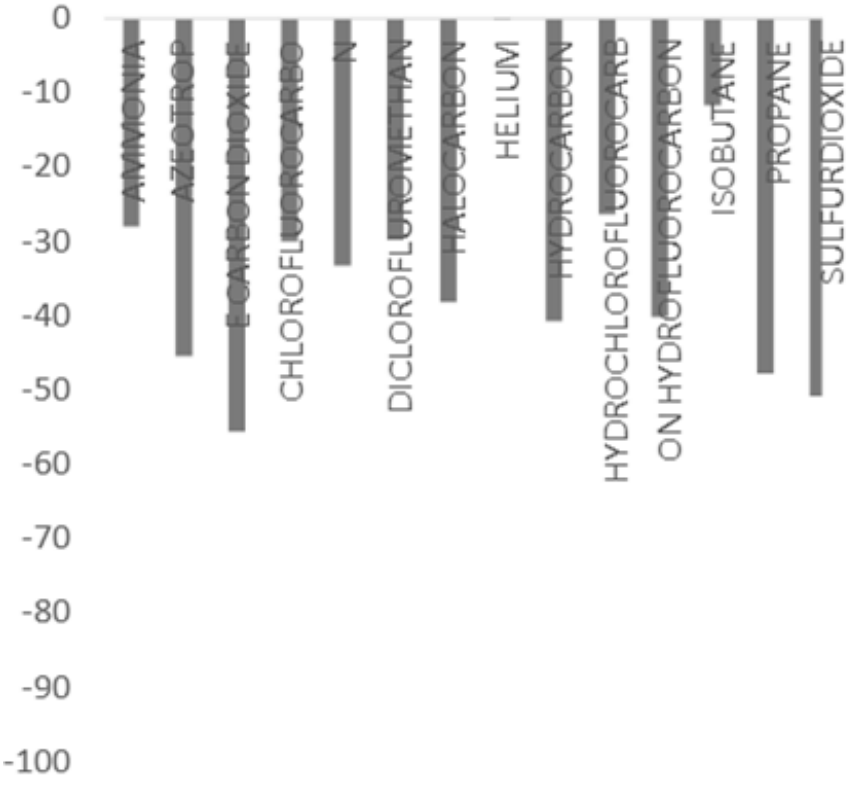
1. Not useful in every component.

Application:

1. Domestic freeze and deep freezer
2. Food preservation.

RESULT AND CONCLUSION

1) REFRIGERANT – BOILING POINT



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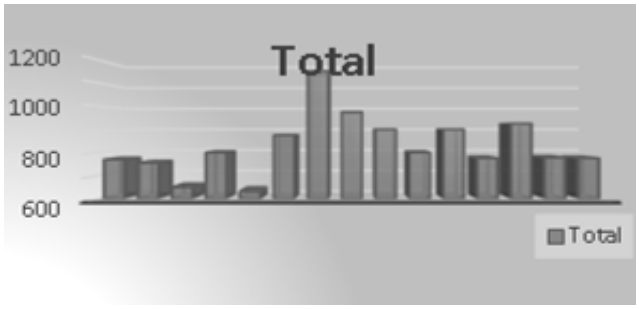
2) REFRIGERANT-VAPOR PRESSURE

SR.NO	REFRIGERANT	VAPOR PRESSURE AT 0* F
1	NH3	16PSI
2	CFC	84.9 PSI
3	HCFC	17.4 PSI
4	CO2	20 PSI
5	C2F4	19 PSI
6	HFC	14.7 PSI
7	C2F6	39 PSI
8	C2H2CIF	45 PSI
9	CS2	5 PSI
10	HC	12 PSI
11	SO2	11 PSI
12	C3H8	14.7 PSI
13	C4H10	13 PSI
14	HE	12.8 PSI

3) REFRIGERANT–FLAMMABILITY

SR.NO	REFRIGERANT	FLEXIBLE LIMIT IN AIR
1	NH3	16-25%
2	CFC	NOT
3	HCFC	NOT
4	CO2	12-75%
5	C2F4	4-10%
6	HFC	NOT
7	C2F6	6-10%
8	C2H2CIF	5-17%
9	CS2	NOT
10	HC	8-12%
11	SO2	NOT
12	C3H8	2-9.5%
13	C4H10	1.8-9.6%
14	HE	NOT

4) REFRIGERANT-COSTING



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CONCLUSION

From the epitomic from all details, we find out that the Ammonia refrigerant is the best suitable options have for every consumer of the refrigeration system. Some of best quality we find out, and that was as per below,

1) Boiling point:--28*c
2) Vapour pressure:- 16psi
3) Cost :-340/kg
4) Density :-0.88gm/cm^3
5) Flammability in the air:16-25%

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