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An Alternative Refrigerant to R134a in VCR System-A Review

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Abstract: *R134a(Hydrofluorocarbon refrigerant) is used in domestic refrigeration and other vapour compression system. R134a is having zero ozone depletion potential (ODP) and almost same thermodynamic properties as R12(Chlorofluorocarbon refrigerant), but it has a high Global Warming Potential (GWP) of 1300.Hence an alternative for this refrigerant is to be identified. It is then necessary to prepare socio-economically acceptable solutions to meet those needs without compromising future international commitments on the protection of the environment, particularly for reducing greenhouse gas emissions and better protection of the ozone layer by use of refrigerants neutral. The performance of heat transfer is one of the most important research areas in the field of thermal engineering. There are a large number of refrigerants, which are used to transfer heat from low temperature reservoir to high temperature reservoir by using vapour compression refrigeration system. There are various obstacles faced in working of different refrigerants due to their environmental impact (R11, R12), toxicity (NH3), flammability (HC) and high pressure (CO2); which makes them more hazardous than other working fluids according to safety and environmental issues. We observed the performance of different environmental friendly refrigerants and their mixtures in different proportions. We also observed the effect of working parameters like dimensions of capillary tube, working pressures and working temperatures, which affect the coefficient of performance (COP) of vapour compression refrigeration system.*

Keywords**:** *Vapour Compression Refrigeration System, Refrigerant, COP, ODP, GWP.*

I. Introduction

India is an important source of GHG emissions and the world's most vulnerable country to climate change. Climate change will affect Indian society. To become the most populous country in the world by 2045, the value of climate change is economically, socially and environmentally. Changing key climate variables, especially temperatures, rainfall and humidity, will likely be affected by key sectors such as agriculture and rural development. Despite its history, it is not a source of pollution; India is currently the fastest growing economy in the world. With the government's goal for gross domestic product (GDP) GDP to achieve biological processes, the share of 1/6 of the world's population and changes in consumption patterns, India's emissions will increase. Strongly. Because of the increasing use of fossil fuels, we tend to be the fourth largest source of greenhouse gases in the world today. Even though our unit's area of emission per capita is the lowest in the world, our growth rate has shown that the past is not a factor in a long term outlook. The latest IPCC report shows that India is expected to see a huge increase in emissions of greenhouse gases and gases worldwide if it maintains a high annual rate of economic growth. The International Energy Agency predicts that India will become the third largest greenhouse gas emitted by 2015. India has imported five large amounts of fossil fuels to meet its energy needs and fossil fuels. For thirty years, India's carbon emissions. Our nearly 70 years of electricity supply comes from coal. The effects have already been observed in the unprecedented wave of heat, storms, floods, salinity of the lines, and they affect agriculture, fisheries and health. The future impacts of global climate change identified by the National Transport Administration (NATCOMs) in 2004 include: Soft soft covers for snow, snow and ice systems such as Stung Ganseng and Ramshed Putheas River. Unusual monsoon has serious consequences for agriculture, rainfall, water, water, and energy. Wheat production ranges from 4 to 5 million tons, which increases the temperature to 1 ° C. Increase the sea level, which leads to changes across the shores of the populated coast, threatening freshwater sources and ecosystems. Increasing the frequency and intensity of floods the increasing vulnerability of the coastal, dry and semi-arid zones of the country.Studies have shown that more than five hundred units of forestry units in India are genuinely skilled in demonstrating changes in affected species affecting biodiversity, changes in zoning, and livelihoods based on Forest products.Some of the key prophecies in the tight reporting of hundreds of years of change are: The local climate models show an average temperature increase of 2.5-5 ° C. In India, India, India, India will have heat.20% increase during the monsoon monsoon. High temperatures and rainfall are expected to rise. All countries may have increased rainfall, except in geographical areas such as the Rattana and Madras. High rainfall can increase, especially in the west and west coast of India. It is likely that the hydrological cycle will be changed. Droughts

and floods will increase. The pools of Krishna, Narmada, Cavours and Tapti may have severe stress and drought. Mahanadi, Godadari and Brahmaputra will have a flood. Crop yield decreases with the temperature and increases with the best rainfall. Wheat production will be reduced. Rabi crops will be the most affected, which will undermine food security. Economic losses due to rising heat have been calculated from September 11 to September 25. Loss of GDP is also 0.67%. Increasing the height of 100 centimeters can result in a net worth of $ 1,259 million in India, equivalent to 0.36% of GDP. The frequency and intensity of tropical storms in the Gulf of the geographical area can significantly increase the amount and floods may increase in the coastal areas. An infection can still be in areas where malaria is severely affected (Orissa, West Bengal, and South Assam).

Vapor-compression refrigeration

The simplest clarification of this method may be a engine operating in reverse, technically said as reverse Nicolas Leonard Sadi Carnot engine. Alternative words, it's the exchange of warmth from a chilly basin to a hot one. Clausius avowal of the Second Law of thermodynamic natural philosophy mention: "It is not possible to build tools that operate in very cycle and generates no result apart from the exchange of warmth from a inferior-temperature body to a high-temperature body".

As the vapor compression cycle is violating the Second Law of natural philosophy, a few works is critical for the exchange to require position.

Vapor compression refrigeration cycles square measure one among the common and versatile refrigeration cycle and acceptable for a large vary of uses from watts to some megawatts. It consists of a mechanical device, condenser, growth device, evaporator and a operating fluid; a refrigerant as seen in Fig. 1.1. A lot of elaborate clarification of the steps is as given below.

Step 1: Compression:

Working fluid goes into the refrigerator in the cold and depressed. It is in gaseous condition. Here, the compression is to increase the temperature and pressure of the refrigerator. Refrigerator release mechanical equipment and enters into the condenser. After all, this method needs work; it can be used by the electric motor, rolling pump, screw, centrifugal grade and reciprocal.

Step 2: Condensation

This kettle is definitely a tool. The heat is transferred from the refrigerator to the water flow. The water is supplied to the cooling system for cooling in the case of cold condensation. Note that water and air cooling strategies can play a more active role. Since the refrigerator passes through the condenser, it is in constant pressure.

Step 3: strangling and growth

If there is a refrigerator into the shock valve, it extends and releases the pressure. So the temperatures have dropped at this stage. In connection with these changes, the refrigerator comes out of the valve, usually a liquid mixture, in the seventy-five to twenty-five attempts to share nothing.

Throttling Valve 2 plays an important role in the vapor compression cycle. First, they kept the difference between the pressure and the invaders low. Second, they control the amount of liquid refrigerator into the evaporation.

Step 4: Evaporation

At this stage, the refrigerated compressed air cycle, the refrigerator is at a lower temperature than its surroundings. So it absorbs heat and evaporates the vapor change. The temperature exaggerated significantly due to the heat absorbed from the heat source to evaporate, while the result is sustained. Compressor discourages relatives helping to keep depression depressed. There square measure a completely different version of the steam on the market, however, a high rating of liquid cooling, square measurements and reliance on air cooling, do not cool the liquid or broadcast their part.

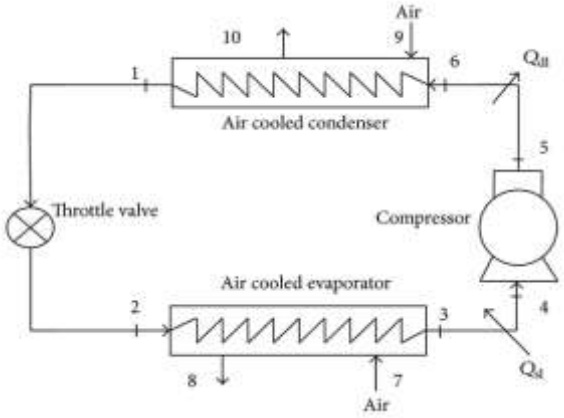

Fig. 1: Basic cycle of domestic refrigeration syste

B. Processes Involved in Vapour Compression Refrigeration System:

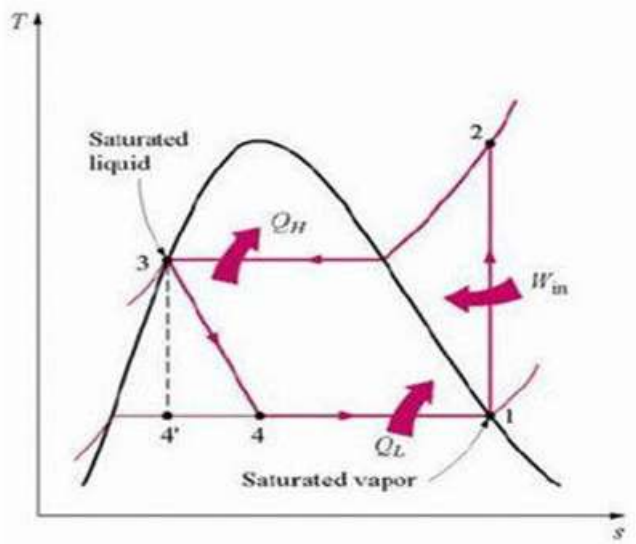

Fig. 2 : T-S Diagram for the Ideal Vapor Compression Refrigeration Cycle

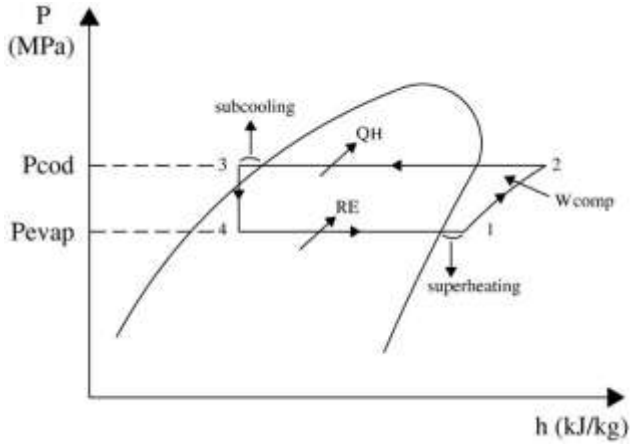

Fig. 3: Pressure-enthalpy graph for vapour compression refrigeration system

Process 1 – 2: Isentropic compression in compressor.
Process 2 –3: Constant pressure heat rejection in condenser.
Process 3 – 4: Isenthalpic expansion in expansion device.
Process 4 –1 :Constant pressure heat absorption in evaporator.

C. Refrigerant:

CFCs (chlorofluorocarbons)

CFC refrigerants like R-11, R-12, R-113, R-114 & R-115 have been used widely in the refrigeration systems & was popular the mid-eighties. CFC production was phased out on First Jan 1996 with Montreal Protocol and was phased out in 2010 in other developing country. The regular CFCs are stable, harmless, non-flammable as well competent, but hampered the Earth's ecosystem.[19] An industry programme to address substitute refrigerants has been initiated by ACRI & is identified as the alternative performance data on substitute refrigerants by conducting tests at participating associate companies with their compressors. The alternatives are to be found for a) Retrofitting b)n replacement for CFCs and HCFC s used in various application. Low pressure application like centrifugal chillers useing R 11 of (about 82 total number of chillers used in the commercial sector. Large tonnage centrifugal chilled water as systems, in navy ships, submarines and air craft carriers using R 114. For high pressure application 18% of large tonnage high pressure centrifugal chillers primarily using r12 and small number using R 500, refrigerators, transport ac using R12, display cabinet, deep freezer, ice machines etc. Using R 502,unitary AC , heat pump using R22. The selection of alternative refrigerant depends on zero ODP and very less GWP. Refrigerant should be non toxic, non flammable ,compatible lubricants and material.The system using alternative should be high energy efficient. Interim suggested refrigerant are R22, R123and long term alternative such as R134a, R236, R 32, R 125, R152a , azeotropes, zeotropes, hydrocarbon and CO_2

HCFC (hydro chlorofluorocarbon):

Hydro chlorofluorocarbon (HCFCs) have been using round about as long as chlorofluorocarbon (CFCs). They are molecules poised of carbon(C), chlorine(Cl), fluorine(Fl) and hydrogen(H). They are fewer stable than chlorofluorocarbon(CFC). R22 is most popular HCFCs across globe. Shorter atmospheric lifetime of HCFC's decreases the potential of ozone depletion. As like chloroflurocarbon, HCFCs are being phased out as mandatory by Montreal Protocol. Production of same is capped in developed countries & is also scheduled in developing countries. This are termed as transitional substances.eg. R-22, R-123[1]

Ammonia (NH_3) or R717:

In refrigerant NH3 has been used since long in industrial refrigeration plants with large capacity. It is environmental promising since NH3 have no effect as green house gas as well does not affect ozone layer. Performance in term of efficient cooling is like R-22, and more favourable. The efficiency is at least as that of R22, even more in some cases. NH3 tends corrosive with copper & containing material, thus preferred material for pipe is steel. [19] Atmospheric N¬¬2 & H2 combines at high pressure in presence of catalyst producing NH3. The Haber-Bosch method is most preferred method for making ammonia. Heat of combustion of ammonia & air is very low since, nitrogen act as inert for combustion or even with reaction with oxygen it absorbs heat from surrounding, thus lower limit of flammability decreases the explosion possibility. Mixtures of ammonia with air is inflammable at concentration of 16-27% by volume in air. However, oil carried by ammonia lowers this level significantly, so a figure of per p.c by volume in air is taken into account the sensible safe limit to stop explosion. Ammonia has wonderful thermal and different physical properties. Ammonia has high heat, which provides rise to a high refrigerant impact per kilogram of refrigerant and thus a smaller refrigerant mass flow for a given duty. Ammonia includes a High COP. Moderate pressure at normal conditions of evaporation and condensation. Ammonia has giant values of warmth transfer coefficients for evaporation and condensation that scale back the scale of evaporator and condenser and thus cost of capital. it'sattainable to induce higher COP by providing smaller temperature distinction for warmth transfer in device. Less resistance loss in liquid refrigerant piping. Ammonia has zero gas depletion potential. Warming potential conjointly zero. Discharge temperature of ammonia is higher for given pressure magnitude relation. Cp/Cv has giant worthone.3.that puts limit on the worth of compression- magnitude relationn ratio and makes it fascinating to supplywater cooling of the mechanical device cylinder and plate. Thermal stability of grease at extreme temperature may be a downside in automatic operation. It's corrosive action on non metallic element metals like copper and brass, in presence of water. Ammonia system use steel or iron. Ammonia is unhealthful and powerful odour that createsleak detection. Ammonia has not mixable with grease. Precaution should be taken for debilitating of oil extractor is employed in discharge line, that removes most of the oil effort with the refrigerant discharge vapour and brings it back to mechanical device crank case. Ammonia promptly dissolve in water and thus just in case of escape willhave an effect on food that typically contains wetness. Regulation of refrigeration injection is tough with littlecapacities as a result of mass flow is comparatively little thanks to giant heat. Ammonia has been introduced as a refrigerant for air con application in numerous region of earth with Asian country. it's typically utilized inreciprocation and screw mechanical device. Lower explosive limit of ammonia is 15-16% in air. Eg 150000 and 160000 ppm or ten times the lower explosive limit of common flammable gases. Ammonia has physical impacts on human for 10-15 years upto twenty four ppm originate no unfavourable effect.

Fluid inorganic thermodynamically is a superb refrigerant for evaporation temperatures in between - thirty five °C to two °C.

Hydrocarbons (HC) as R-290, R-600a:

Main component of HC are Hydroger (H2) & Carbon (C). HC refrigerant typically used as various for chlorofluorocarbon and hydroflurocarbon refrigerant HC could be a natural refrigerant. This is often primarily propane (R-290), iso-butene (R-600a). These fluids have sensible natural philosophy properties, however are dangerous owing to their inflammability. the globe of the cold has invariably been cautious of those fluids, even though they need reappeared recently in refrigerators and insulating foams. hydrocarbon have vapor pressure kind of like those of the gases they replace chlorofluorocarbon twelve, except R-600a whose absolute pressure is concerning almost half that of R-12.

- **R290**:

It's primarily propane and use as a refrigerant. The formula of R-290 is C_3H_8. Ozone diminution potential is zero & heating potential is three. This refrigerant appropriate for refrigeration and air-con applications. R-290 use will increase because of its ecofriendly as well sensible thermodynamics(T) property. Vapor pressure is 7.6 bar at 20 degree C. R-290 could be a inflammable refrigerant and lies in A3 cluster as per ASHRAE safety category. Lower inflammability limit is approximately 2.1 percentage of volume and higher inflammability limit is approximately 9.4 percent of volume. Burning rate of R-290 is forty six cm/sec. machine ignitiontemperatureis478^0degreeC.

- **R-600**:

It's a primarily alkane series(C4H10) and used as refrigerant. Ozone diminution potential is almost nil. This refrigerant appropriate for refrigeration and AC applications. R-600a use will increase thanks to its ecofriendly and sensible physical science property. heat of evaporation is 0.3665 MJ/Kg. vapor pressure is apprximatly 2.1 bar at 20 degree C. R-600a could be a inflammable refrigerant and lies in A3 cluster as per ASHRAE safety category. Lower inflammability limit is approximately 1.3 percentage of volume & higher inflammability limit is approximately 8.2 percentage of volume. Burning rate of R-600a is forty four cm/sec. machine ignition temperature is 460 degree C. R-290 & R-600a utilized in bottle cooler, house hold refrigeration and water dispensers, vehicle,stores, cooling, industry, HC compatible with lubricants. This refrigerants are soluble with all oils, including,mineral, group aromatic hydrocarbon & polyester sorts. Energy potency of polyester sorts. Energy potency of system victimization organic compound ai concerning 100 percent quite fluorocarbon charge vapour compression units. Refrigerant (HC) charge is often solely four-hundredth of the fluorocarbon equivalent. HC have less region life, sinking their impact on the environmental if free in atmosphere

- **R744 (CO_2):**

This is often inorganic, non-toxic, non inflammable, however inefficient in physical science. Its use would involve high and special compressors. Currently, specialists in air-con and refrigeration have an interest once more by: Its low environmental impact (ODP= zero, GWP = 1); the low specific volume leading to facilities with low volume (small leak); it's the excellence of getting a coffee crucial temperature at 31°C at a pressure of seventy three.6 bars. Its boiling purpose is -78.5oC & the melting point is fifty six.6oC at air pressure. It is odorless, non-toxic, non-flammable, non-explosive & non-corrosive. At air pressure, it sublimates from solid state to liquid state manufacturing cold at worker of -78.5oC. It doesn't wet the surface to bear throughout sublimation. Therefore, it's accustomed preserve the eye-bowl (inner portion) in its state throughout eye operation. Carbonic acid gas appropriate for cold application. The load of carbonic acid gas is concerning 1/2greenhouse emission refrigerant. Carbonic acid gas system are often designed additional cheaply than the comparable halocarbon system. Carbonic acid gas system run additional expeditiously than greenhouse emission machine and thus have lower running price and Maintenance price is lower. carbonic acid gas as a replacement of R22 in low freeze drying plant acting at -500C, CO2 is extensively utilized in America, UK and European countries. Mobile air-con system in cars area unit a significant supply of inexperienced house gases. Most climate management systems for automotive area unit supported the greenhouse gas R-134a and every one the key European car manufactures are testing CO_2 technology for a few time with glorious results. Denso corporation (Japan) has developed CO_2 compressors appropriate for automobile A/C. It's been accustomed replace NH_3 in ice rinks in europe. It's a primary refrigerants utilized in cooling. CO_2 gas wide utilized in marine

refrigeration and for A/C in public places wherever safety is prime importance. With introduction of greenhouse emission and similar refrigerants its use was restricted to cold applications such as production of solid CO_2. Major disadvantage of CO_2 is its high working pressure. At -15degree C evaporation and 30 degree C condensation temperatures having pressure a 2254 Kpa and 7180 Kpa resp. Sufficiently higher than NH_3. CO_2 need safety and security precautions should be noted with pressurised system related to CO_2.

HFC (Hydrofluoro carbons)

HFC includes carbon(C), fluorine(Fl) and hydrogen(H) & not clorin (Cl) eg.R-134a, R-152a etc. [1]

- **R-134a:-**

HFC-134 (Tetrafluoroethane) has least ozone reduction potential with close properties to R-12. Chemical represented by CH_2FCF_3 having boiling point of -26.3 degree C. Table no.1 presents vapour pressure is 665 KPa at 25 degree C and 2.63 at 83^0C.Zero ODP and !410 GWP. It is a colourless gas and molar mass is 102.03g/mol. HFC 134a is a non flammable at 100^0 C.

Table 1: Properties of R134a [7]

Molar Mass	102.03 g/mol
Appearance	Colourless
Boiling Point	-26.3 ºC
Critical Point, Tc	102 ºC
Pvap, MPa (25°C)	0.665
Pvap, MPa (80°C	2.63
ODP	0
GWP	1410

R-134a is almost completely immiscible with usual mineral oil based refrigeration oils and also with a numeral of synthetic lubricants. The synthetic compound oils are found miscible with R134a and others include polyalkylene glycols (PAGs). Polyglycols have given remarkable result in test ring trials with open type refrigerant compressor and their extremely hygroscopic behavior makes them difficult to handle. As such easter-based synthetic lubricants have been the first choice for some time now, as they less hygroscopic in nature compared with PAGs.

R134a does not form inflammable mixture with air under normal conditions. i.e. atmospheric pressure. Inflammable mixtures would form at pressures above atmospheric if the air components in the mixture exceed 60%. In leakage checks or pressure tests this refrigerant must never be used together with air or oxygen.R134a is also safe toxically. Experimentation provides data proving safe use at various occasion. The European Union (EU) countries has taken the course of continuing down the legislative path so as to do deal with possible potential consequences warming. On Jan , 2006, the EU assembly passed legislation forbidding the equipment of R-134a systems altogether new vehicle sorts from Jan 2011, and altogether every vehicles from Jan 2017.Under this legislation, the substitute refrigerants should have a GWP of below a hundred and fifty. It has a positive pressure in evaporator and hence there is no necessity of purge nit and vacuum prevention systems required on negative pressure chillers. There is no refrigerant loss through purging. The performance penalty in the form of additional power consumption due to non condensable gases and moisture in negative pressure chillers is not applicable to R-134a units. It has good system efficiency and good availability because of its variety of application. It is not compatible with conventional mineral lubricating oils and needs polyester based synthetic oils, which are highly hygroscopic and hence utmost care is required while charging and servicing. Its theoretical efficiency is less than that of many refrigerants. It has higher specific volume and requires a large displacement.

- **R152a:-**

Diflouroethane(R-152a) is an organic fluorine represented as C2H4F2. Even if R0152a is havin ozone depletion potential, but shorter atmospheric lifeteome reduces the dangure, thus is approved refrigerant for vehical in repalcemne to R-134a. Table 2 indicate: It is a color less gas .ODP is zero and GWP is 120. Vapour pressure of R152a is 5.1 bar at 20^0C.It is flammable gas. Bottom inflammability range is aprroximatly 3.9 % by volume and top inflammability range 16.9 % by volume. Auto ignition temperature is 454^0C.As per ASHRAE 34 R152a is A2 type refrigerant.

Table 2: Properties of R152a [3]

Molar Mass	66.05 g/mol
Appearance	Colorless
Melting Point	-117 °C
Boiling Point	-25 °C
Solubility in water	0.54 wt%
ODP	0
GWP	120

Diflouroethane (R152a) is synthesised from hydrogen fluoride & acetylene in presence of HG as catalyst. This process involves vinyl fluoride to produce, with the monomeric precursor to polyvinyl fluoride.

$$HCCH+2HF \longrightarrow CH_3CHF_2$$

Though not very inflammable in gaseous form R-152a, can burn under limited circumstances. As such, additionally a warning label labelled on some gas dusters. once inverted to spray liquid the boiling FC aerosol is definitely ignitible developing a really giant blast of flame and intensely poisonous gases like HFl and carbonyl fluoride as combustion product.

- **HFO**

The chemical structure of pure fluids like SolsticeR ze, SolsticeR yf and SolsticeR zd contains a carbon-carbon covalent bond that may be a key feature facilitating the low heating characteristic. These molecules even have low part lifetimes. HFOs square measure composed from element, chemical element and carbon compounds kind of like HFCs, however they're structurally totally different. HFOs have terribly short part life resulting in distinct environmental edges. HFOs square measure subject to all or any legislation that applies to the availability and use of chemicals, together with reach within the Montreal Protocol, EPA SNAP, F gas regulation. HFOs square measure the fourth generation of refrigerants, with every generation being a step-change improvement on the previous generation. HFOs possesses same qualities as of HFCs, however with terribly low GWPs (Global Warming Potential) and nil ODP. European Directive on mobile air-conditioning systems (MACs) to cut back emissions of fluorinated greenhouse gases has semiconductor diode to the utilization of HFOs as potential refrigerants in air-conditioning of all new vehicle kind, that in-turn bolstered the market growth.In terms of application, air-conditioning and refrigeration square measure the two leading application of HFO refrigerants. Rising international economy and per capita disposable incomes in particularly developing nations, the demand for refrigerants is predicted to flourish within the returning years. Moreover, increasing consumption of refrigerants in end-use trade like food & beverages and cars sector not to mention improved living standards resulting in billowy demand for air-con square measure some major factors propellant the expansion of the world HFO market. Further, increasing usage of mobile air-conditioning and hard-hitting chillers particularly in business refrigeration is another major issue driving the growth. Further, the environmental consideration like ozonosphere depletion and heating related to the utilization of ancient refrigerants have semiconductor diode to the formation of strict protocols and rules, this can be also will support the expansion of low GWP different like HFOs. Based on kind, HFO 1234yf section dominated the world market in 2016 and is predicted to take care of its position throughout the forecast amount as a result of increasing shopper awareness towards atmosphere protection not to mention strict rules on the utilization of risky and ototoxic refrigerants in mobile air-conditioning and refrigeration. HFO-1234yf section is followed by HFO-1234ze in terms of value share. Increasing demand from chillers and processing agent applications is projected to drive the HFO-1234ze section over the forecast amount. The presence of the carbon-carbon covalent bond isn't distinctive for HFOs as there square measure alternative unsaturated compounds to be fond, as as an example unsaturated hydrocarbons (e.g. propene). In fact, HFO-1234yf may be a propylene molecule that's halogenated by substitution four atoms of element with four atoms of chemical element explained in figure 1.

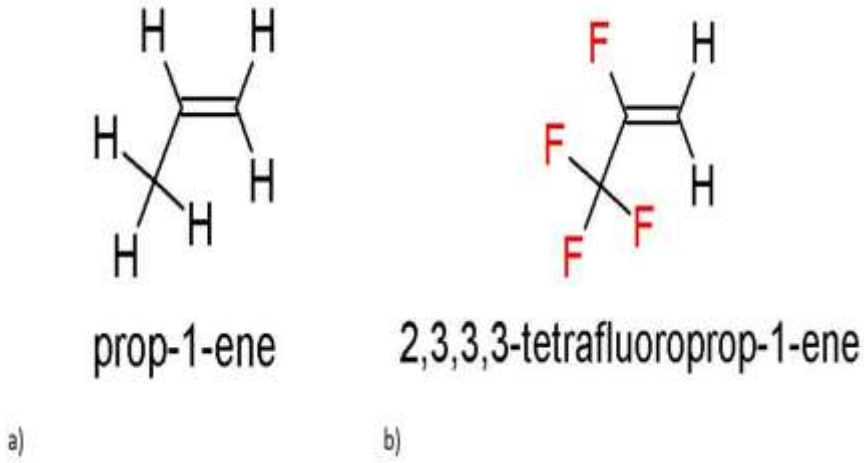

Fig. 4– Structural formula of propene (a) and HFO-1234yf (b)

Table 3: Properties of R1234yf

Refrigerant	R1234yf
Chemical name	2,3,3,3- tetrafluoropropene
Product group	Hydrofluorolefin-(HFO)
Preferred oil	Poly Alkylene Glycol (PAG) formulated for R-1234yf-(Polyolester(POE))
ASHRAE safety classification	A2L-(non-toxic & mildly- inflammable)
Boiling Point	-29 degree C (at 1atm)
Critical Temperature	95 degree C
Critical Pressure	34 bar(a)
ODP	0
GWP	4
GWP as % of R-134a	0.3%

HFOs are relatively stable compounds, but are more reactive than HFC due to the reactivity of the carbon–carbon bond. This also reduces their global warming potential and therefore became favorable property in light of increasing concerns on climate change.

- **3.6.1.5. Environmental effect**

The interest to HFOs as potential refrigerants arose with the adoption of European Directive 2006/40/EC on mobile A/C systems which intend on dropping emissions of fluorinated greenhouse gases in the cooling systems of vehical. It therefore, de facto, banned the long term use of R134a refrigerant, which is itself came as an environmentally friendly replacement to R22 just a dozen years before the Directive. Fluorinated propene isomer R1234yf has become a refrigerant of a choise and many cars manufacturers have adopted new refrigerant in nearly 50 vehicle models [1].

Unlike R-134a, new refrigerant has very low effect on global warming. This feature is common for other HFOs, for a number of which their integrated over hundred yr. participation to global warming is lesse than that of CO_2 [2]. This is mainly due to their short lifetime that is within a couple of weeks for many HFOs (see Table 1)

Table 4: Lifetime and global warming potential of some HFOs [2].

Refrigerant	**Chemical formula**	**Lifetime, days**	**GWP (100 yr.)**
HFO-1234yf	$CF_3CF=CH_2$	10.5	<1
HFO-1234ze(E)	trans-$CF_3CH=CHF$	16.4	<1
HFO-1234ze(Z)	$CF_3CH=CHF(Z)$	10.0	<1
HFO-1336mzz(Z)	$CF_3CH=CHCF_3(Z)$	22.0	2

- **Safety**

The experience suggests that there is no single best refrigerant as, when selecting refrigerant, one normally faces trades off between different criteria. In case of HFOs the benefits on the environmental side are partly outweighed by the concerns on their safety.

The concerns on safety of HFOs were in particularly raised by Daimler AG, when the company made the decision to discontinue usage of HFO-1234yf in some of their car models [3]. The decision was followed by a number of tests that showed potential danger of flammable HFO use in MACs. The results were questioned by refrigerant manufacturer, that claims that "neither flammability nor HF formation present a significant safety concern" [4]. The potential danger of HFO-1234yf in MACs thus led a number of car manufacturer to look after alternative MAC system designs [5]. In particular, Volkswagen has already announced the use of CO_2 based systems in selected models of cars [6].

It is therefore 2 main safety issues that are related to HFOs: flammability and their potential to form dangerous acids. A number of HFOs, including HFO-1234yf, HFO-1234ze(E), are flammable, while others are not, as for instance HFO 1336mzz(Z) and HFO-1233zd(E). Like any other the halogenated hydrocarbons, HFO is easily decomposable under the influence of high temperatures to form hydrogen fluoride - the highly soluble in water gas that easily form acid, that would cause skin irritation, eye irritation and throat irritation and could lead to death [7]. It is quite obvious that flammable refrigerants have greater probability to get under effect of high temperatures and therefore bring greater risk of formation of dangerous substances.

- **Status of HFO**

HFO, being technically HFCs, are surprisingly given special rights by many. For instance, the newly adopted EU Regulation on fluorinated emission of greenhouse gases eliminate HFOs from known definition of ''hydrofluorocarbons'' and, hence, do not include them in their ambitious schedule of the diminution of the amount of HFC's. Japan accept similar conduct and disconnected a number of HFOs from their "the act on rational use and proper management of fluorocarbons" that has recently came into effect

II. Literature Review

K. Mani and V. Selladurai [1], have analyzed a vapour compression refrigeration system with the new R290/R600a refrigerant mixture as drop-in replacement was conducted and compared with R12 and R134a. The VCRS was initially designed to operate with R12.Theresults showed that the refrigerant R134a showed slightly lower COP than R12. The discharge temperature and discharge pressure of the R290/R600a mixture was very close to R12. The R290/R600a (68/32 by wt %) mixture can be considered as a drop-in replacement refrigerant for R12 and R134a.

A.S. Dalkilic and S. Wongwises [2], have studied the performance on a VCRS with refrigerant mixtures based on R134a, R152a, R32, R290, R1270, R600 and R600a was done for various ratios and their results are compared with R12, R22 and R134a as possible alternative replacements. The results showed that all of the alternative refrigerants investigated in the analysis have a slightly lower COP than R12, R22, and R134a for the condensation temperature of 50 °C and evaporating temperatures ranging between −30 °C and 10 °C. Refrigerant blends of R290/R600a (40/60 by wt. %) instead of R12 and R290/R1270 (20/80 by wt. %) instead of R22 are found to be replacement refrigerants among other alternatives.Vincenzo La Rocca and Giuseppe Panno [3], have analyzed and compared the performance of a vapour compression refrigerating unit operating with R22, and with three new HFC fluids, substituting the former according to Regulation No 2037/2000. Here the plant working efficiency was first tested with R22 and then with three new HFC fluids: R417a,R422a and R422d. It is analyzed that the performance with the new tested fluids did not result as efficient as when using R22. Vincenzo La Rocca and Giuseppe Panno [4], have analyzed and compared the performance of a vapour compression refrigerating unit operating with R22, and with three new HFC fluids, substituting the former according to Regulation No 2037/2000. Here the plant working efficiency was first tested with R22 and then with three new HFC fluids: R417a, R422a and R422d. It is analyzed that the performance with the new tested fluids did not result as efficient as when using R22. Minxia Li, Chaobin Dang and Eiji Hihara [5], have investigated that Hfo1234yf has been proposed for mobile air-conditioners due to its low GWP and performance comparable to that of R134a. However, its performance is inferior to that of R410a. This makes it difficult to be applied to residential air-conditioners. In order to apply the low GWP refrigerant to residential air-conditioners, refrigerant mixtures of Hfo1234yf and R32 are proposed, and their flow boiling heat transfer performances were investigated at two mass fractions (80/20 and 50/50 by mass %) in a smooth horizontal tube with an inner diameter of 2 mm. The results showed that the heat transfer coefficients of the mixture with an R32 mass fraction of 20% were 10–30% less than those of pure Hfo1234yf for various mass and heat fluxes. When the mass fraction of R32 increased to 50%, the heat transfer coefficients of the mixture were 10–20% greater than those of pure HFO1234yf under conditions of large mass and heat fluxes.Kyle M. Karber et al. [6], found that

R-1234yf is more suitable than R-1234ze to replace R-134A and he two refrigerator setup for refrigerant. In Refrigerator 1 and 2, R-1234yf had 2.7% and 1.3% higher energy consumption than R-134a this indicates that R-1234yf is a suitable for replace R-134a.In Refrigerator 1 and 2, R-1234ze had 16% and 5.4% lower energy consumption than R-134a. Thus R-1234ze might not be suitable for drop-in replacement. Barbara Minor et al. [7], conclude that HFO-1234yf has excellent potential as a new low global warming refrigerant for automotive air conditioning and potentially for stationary applications. It has excellent environmental properties which can have a long term favourable impact on climate change and meet current and future climate regulations. Significant toxicity tests have been completed with encouraging results. It is compatible with existing R-134a technology which can allow for a smooth and cost effective transition. The mild flammability properties of HFO-1234y have shown its high potential for use in direct expansion applications, pending completion of risk assessments.

Thomas J. Leck [8], evaluate that HFO-1234yf as a Potential Replacement for R-134a in Refrigeration Applications. This paper presents results of work to develop a Martin Hou equation of state model for calculation of thermos-physical properties of this new. M.Abuzar Qureshi [9] et al,In this paper analyze of COP victimisation R134a & R600a Refrigerant in Domestic white goods at steady state condition. 2 totally different refrigerant square measure R600a (Isobutene) and R134a (tetrafluoroethae).R134a is zero gas depletion layer and high international warning and R600a is zero gas depletion layer and negligible international warning. In domestic white goods was hand-picked by the obtained result from R134a associate degreed an experiment victimisation fifty g of R600a that indicate the similar result as R134a.Based on outcomes R600a charge quantity, condenser evaporator and mechanical device constant of performance were hand-picked for style. associate degree experimental is calculated by comparison the coefficent of performace victimisation refrigerant R-600a (Isobutane) and R-134 (tetrafluoraethane) at stedy state condition. constant of performance of R600a was higher vary of forty.86%-46.54% than R134a at Constance refrigerant result 45W and Constant evaporating temperature. constant of performance of R600a was higher vary of eighty three.33% than R134a at Constance refrigerant result 30W and Constance evaporating temperature. refrigerant capability of R-600a is more than R-134a.The discharge temperature of mechanical device is shriveled with 100 percent by victimisation R600a mechanical device energy consumption white goods step by step decrease with third-dimensional of compared to traditional R134a domestic mechanical device white goods. A Domestic white goods with used one hundred fifty g of refrigerant R134a shows that mechanical device had the very best quantity of energy destruction followed by the condenser, capillary tubing, and evaporator. The optimum condition was found to be R600a charge quantity fifty g mechanical device very cheap quantity of energy destruction followed by the condenser, capillary tubing, and evaporator. The mount of charge needed for R600a is fifty g, 66%lower than R134. Energy consumption beneath the take a look at condition, once tested in accordance with relevant customary as R600a is 264 unit each year and R134a is 302 units each year. N Austin [10], during this paper, analyze the performance of vapour compression refrigeration systems with numerous refrigerant mixtures like R152a, R32, R290, R1270, R600a and RE170 thereto of vapour compression refrigeration systems victimisation R134a, CFC22, CFC12, and R134a. this can be drained order to search out the chance of another or replacement to the normal refrigerants. Despite the properties of HC refrigerants like high flammability it's employed in several applications. but careful observance of the outpouring from the system is completed thanks to questions of safety. this can be as a result of in contrast to alternative refrigerants HC refrigerants square measure directly associated with heating and layer depletion. The outcomes proven that among the replacement refrigerants studied within the analysis, R152a, RE170and R600a possess a commendable performance constant (COP) compared to CFC12, CFC22 and R134a. system of a perfect vapour-compression cycle is formed use for the analysis of recent refrigerants. once the performance coefficients (COP) comparison and tested refrigerants pressure quantitative relation square measure taken into thought at the side of the numerous environmental factors, HC290/HC1270 (20/80 by wt.%) and HC290/HC600a (40/60 by wt.%) and RE170 refrigerant blends was thought to be the foremost appropriate replacement among refrigerants tested for R12, R22 and R134a.The system performance constant (COP), will increase with elevation in temperature of evaporation for a temperature of static condensation. By examining the consequence of super heating / sub cooling case, all ways together with numerous refrigerants were improved. the results of performance analysis like class of refrigerant, sub cooling degree and super heating on the consequence of refrigeration, performance constant and capability of volumetrical refrigeration etc., were conjointly examined for various evaporation temperatures. As a results of this improvement, a stronger worth of performance constant (COP) is obtained. Safvan Khansaheb et a [11], In considering and analyzing this type of thermodynamic properties of R134a, however, there is a high GWP above GWP 1300, due to the emission from R134a, the family unit has long lived in the manner to implement the error implementation. Various air-conditioners, fridge, power-efficient interaction, security and repair environments. The City Center, the United Nations Framework Convention on Climate Change (UNFCCC), requires cutting-edge greenhouse gas emission reductions, together with fluorocarbons (HFCs). On the environmental and medical field environment of reading, it is important to look at some super cool alternatives

to HFC. Considering the mixed literature of hydrocarbons (R290 and R600), the mixing performance is reasonable in a small possibility of local commodity compared to the R134a. In India, in the cult of the Eighties, the local refrigerator using the R134a Refrigerator from his remarkable thermometer and thermo physical attributes. Akintunde. M.A [12], This article is the heat physiological phenomenon and the dissemination of 2 refrigerant mixers that are developed methodically. The aim is to analyze and repair both a mixture of regional warmth to R12, which is one of the most profoundly damaging gases. Transient hot Wire (THW) method is used temporarily in the study to live in the body and heat diffusion 2 refrigerant mixture. Both the refrigerator RA1 AP (50% R600a / 50% R134a) and RA2 (70% R600a / 30% R134a). After 2 Refrigerator Mixes was created by Utulu (2012). They used for deigned family runners to R12 (CF2Cl2). This thermal and heat-diffused heat of the mixture is measured at a temperature of different than three hundred K and 315 K, and the pressure varies from zero.1.13 MPa and compared to that of the R-12 under the same experimental conditions Is maintained saturation condition in a 12th R-liquid state, it has been found that RA1 and RA2 each, to have zero.0816 write / mK and 0.0957 write / mK. It has been found that values that are paired with 9% and 20,68% break apart at the top of the heat values of the physical phenomenon R12 under these experimental conditions. Add the value of the promotional coefficient is detected for each and RA2 RA1 to be a pair of.7634 X 10 of 8sq.m and a pair of.74386x10-8 m2 of equity / s in the R-12, it must It was found that it was a time of .43772x10-8 m2 / s. This shows that the prices for RA1 and RA2 are twelve.56% and 13.38% separately for the peak of the R12. The purpose is to use RA1 and RA2 as one or more alternatives to R12. With this experimental result and the previous Utulu (2012), every refrigerator for the macaws suitable, as opposed to R12. The set is found not to be found in the COP or RA1 before falling under RA2 with the same R12 as the thickness. Since the measurement is measured within temperature is made different from three hundred K and K and the pressure 315 varies from zero.5 to 1.13 MPA, the result is its different external validity. The error of the decision mentioned, the uncertainty of the device is to have the computer zero.071% and 0.078%, separately for RA1 and RA2.M. Boumaza [13] , it's evident that these days, many new refrigerants whether or not pure, mixtures or naturals, ar projected to exchange R22. R290 (propane), R600(iso butane) and R717 (ammonia), that ar thought of natural refrigerants, appear to be the simplest potentials candidates to use refrigeration, air con and warmth pumps. Beside being environmental and layer friendly substances, new lubricants have additionally been developed to work with these refrigerants. this analysis has enabled to point out that: Performance of vapour compression system decreases with increasing out of doors temperatures. R 290 could also be directly used a substitute to R22, for smaller refrigeration load. Ammonia that possess glorious physics performance, and covers a good vary of refrigeration temperatures, each positive and negative, needs specific materials thanks to its dangerous physical properties. R600a, AN environmental friendly refrigerant possesses a coffee vapor pressure and provides so a coffee refrigerant load. It may be used for domestic refrigeration, requiring a positive refrigeration. Fluids having low crucial temperature exhibit a crucial decrease in cooling capability. Rate of mechanical device power increase is analogous for all fluids. The new refrigerants studied have lower mechanical device discharge temperatures than the R22, and thus would require compressors in operation underneath less sever conditions. Anas Farraj et al[14], In this study, the performance of 1 ton of cracking blocks (A / C) was investigated. The unit was originally designed to use R22 Refrigerator. Fossil gases in liquid fuel (LPGM), about R-600 (weight ratio), is evaluated as a droplet by replacing R 22. This work is part of a global effort to find alternatives for chlorofluorocarbons and hydro chlorofluoro carbons. Wear the gases and climate change that provide these efforts. The well-known fact that Air Conditioning (A / C) uses energy includes a large portion of the total energy use of the building industry. The result of the electric star who tried to power this. The voltaic array of photographs of the twelve modules is used as the power of the electric grid. Study the capacity of the refrigerator unit to use in the same way relative to each other. Experiments are allocated for running one day. The efficiency parameter is studied as an inverse variable, such as: constant performance (COP); Power; Energy consumption; Thermal transfer and the mass of the refrigerator. In addition, the change in independent variables such as: the temperature (tea); And the condensation temperature (TC) was evaluated. In fact, it has been found that the COP in the operating system is an LPGM coolant, and hence the possibility of at least a square to operate is no R-22. Each of the CSs and hence, at least twenty-five square miles of capable infrared under best conditions. Despite this LPGM, there are different blessings, such as higher efficiency; Low mass flow rate; The lower the mechanical temperature in the low-power utility output. It has been found that the utilization of the operating time with mechanical equipment is not the fifth LPGM before the R - 22 operations. Plus it provides LPGM used in R22 refrigerator for change, this especially after steam / C powered by an energy source.

N.Suguna Ramu et al[15], During this operation, the evaluation of the energy efficiency of the fridge compressor system was evaluated on the paper by R22 and the mixture, thus ternary with R32, R125 and 600a different. The estimation of the energy efficiency of the cooling system, which has been developed for three different absolute condensation temperatures, such as thirty five, forty five and 55oC, has an evaporative temperature and 10oC between -10 (cool medium temperatures and a condenser) . Assessments are made in

terms of normal operational parameters, such as energy consumption (COP), which are energy consumption, mechanical equipment, temperature, output, and volumetric cooling capacity (VCC). The total cooling heating system (TEGWI) has been evaluated for experimentation. The result shows that the VCC refrigerator mix has R32 / R125 / R600a (in relation to zero.4, the value: 0.4: 0.2, with weight) is closer to R22. So, the new refrigerant mixture can be used as a drip by replacing R22 in the existing system. The COP mix was found not to be one with R22, considering 16-20% in condensation and evaporation of any temperature. The mechanical temperature of the refrigerator mixture of this new device was found not before 6-11^{o}C with R22, indicating that the life expectancy of the mechanical device could be expected to be a new refrigerator. The TEGWI mixes the last refrigerator, which is higher than about 2 months R22 due to its high fibre mechanics. The results indicated that the new refrigerator was a mix of different ozone dyes to complete the R22 in the existing cooling system, in order to enhance its service life rather than modification. In addition, improvements to the request efficiency for the square system described at least. M. Mohanraj et al[16], 134a is that most commonly used refrigerator in household fridge. It should be terminated now, according to the Kyoto protocol, adding high potential heat (GWP) 1300 gift in operation, associate degree associate is created with organic freezer mix (available R290 and R600 in a ratio at one value forty five.2: 54.8 by weight) of R134a alternatively within two hundred litres of internal evaporator fridge. Continuous running tests are carried out under completely different temperature extremes (24, 28, 32, thirty-eight, forty-three, ◦ C) while the game is working (/ close), the right test exclusively reserved to temperatures ◦C near thirty-two. The results showed that organic compounds of low-cost mixtures of energy use; Extract time and time values of over eleven.1%, 11.6% and 13.2% together with high performance 3.25-3.6% fixed (COP). The temperature was found at the outlet of the organic compound mixture to be 8.5 to 13.4 K, not earlier with the R134a. Performances, including the higher experience of mixing organic compartments, can be very simple to end the long-term perspective R134a. Akintunde, M.A. [17] the chlorofluorocarbons (HF) phase out, determined in the future to meet the different requirements in terms of performance and maintenance, the system is an analysis of the living space in the refrigerator and measures Square of business acquisition. This work is focused on the experimental practice of refining the environment-friendly refrigerator. The following three mixtures are: R600a (n-butane), R134a (1,1,1,2, tetrafluoroethane) and R406A (55% R22 / 4% R600a / 41% R142b) are considered for this analysis. One of these mixtures in these are studied proportionally and compared with R 12 (dichlorodifluoromethane), which is used as a test for the experiment. Used in the drilling station, this can be a local (1,492 kilowatts) freezer, considered to support condensation and temperature evaporation. This apparatus was tested by R-12 and a mixture of three. Throughout this experiment, the evaporation temperature has been measured. They are used to check the absorption heat in the evaporator and the heat excluded. The results show that the R134a / R600a mixture is in the range of 50:50 Fuel Ratio is often used differently from R-12 domestic fridges and does not require repairing of mechanical oils. B and R-12 provide a COP while two.08 50:50 a mix of R134a / R600a offers a similar COP 2.30 in under operation.AE Kharat et al[28], The gas Depleting Potential (ODP) and warming potential (GWP) became the foremost necessary criteria within the development of latest refrigerants excluding the refrigerant CFCs and HCFCs, each of that have high ODP and GWP because of their contribution to ozonosphere depletion and warming. Results from researchers show that the ozonosphere is being depleted because of the presence of halogen within the layer. the final accord for the reason behind this that CFCs and HCFCs square measure giant category of halogen containing chemicals, that migrate to react with gas. This ends up in the strict prohibition Of CFCs. The R134a was the primary chlorine-free refrigerant discovered .Bolaji [118],. R134a is employed today because the operating fluid in domestic refrigerators. however it absolutely was found that the R134a increasing considerably to the world's greenhouse warming drawback. This caused scientists to research additional surrounding sally friendly refrigerants than greenhouse emission refrigerants for the protection of the environment like organic compound mixtures as operating fluid in refrigeration and air-conditioning systems. the chance of exploitation organic compound mixtures as operating fluid to exchange R134a in domestic refrigerators has been evaluated through the simulation analysis. This simulation concludes that the organic compound refrigerants provide fascinating environmental necessities i.e., zero ODP and just about zero GWP. A organic compound mix of difluoromethane (R32), gas (R290) and iso-butane (R600a) is usually optional to avoid the stratospheric gas reduction. The attendance of R600a within the combination is mixable by means of each oil and artificial lubricants. Abinesh.T et al[19], Experimental investigation were administrated with an alternate eco-friendly refrigerant with higher co economical of performance (COP), reduced gas Depletion potential (ODP), and warming Potential (GWP). This exploration has been access employing a organic compound refrigerant combination compose of R152a/R290/R600a within the quantitative relation of 70:25:5 by mass and by another refrigerant R134a. The presentation description of the household white goods was foretold exploitation unremitting running test beneath totally dissimilar close temperatures. The obtain grades show that the organic compound combination has lower values of energy expenditure, pull down time and ON time quantitative relation even have higher co-efficient of performance (COP). Therefore the recital of the alternate refrigerant derives the higher selection than R134a. R. S. Powade et al[20], air con system works on

principle of vapour compression refrigeration cycle. potency of air con system depends on the properties of refrigerant. however presently used refrigerants (HCFCs) like R12, R123 has great amount of world Warming Potential (GWP) and gas Depletion Potential (ODP). per urban center protocol and urban center protocol these refrigerants ar secure to be prohibited when 2020. one amongst the ways in which to scale back GWP and ODP is that the use of different ecofriendly refrigerant like organic compound and mix refrigerant mixture. during this study, analysis of performance of 2 various refrigerants, R290 and R134A, in conjunction with R22 ar done. Experiments were perform on totally different refrigerant below planned conditions by considering varied performance parameters like refrigerant mass flow, cooling capability, energy potency quantitative relation, constant of performance, and mechanical device work. One ton of refrigeration (1TR) cooling system is intended and fictional to analyze the performance of R290 and R134a. Cooling capability of R134a is lower in vary 18%- twenty two.5%and that of R290 is 9%-10.25% less than R22. Energy potency quantitative relation of R290 is nine.90% lesser than R22 and R134a is best than R22 by seven.52 %. Optimize mass amount of R290 is five hundredth but R22 and R134a is 22%lower as compared to R22 in window cooling system.

Sharmas Vali Shaika et.al [21], Physical science research on many different effects, the following conclusions can be made. The Internet affects the cold exposure and mechanical operation of the equipment for the ternary R134a / R1270 / R290 (50/5/45 weight as the weight) provides the COP (3608), a pair of.10 A higher percentage of R22, R431A, R410A, R419A, R134a, R1270, R290, and fifteen refrigerator units included R134a, R290 and R1270. The study shows that each of the sixteen ara mixtures is slightly refrigerated, which is investigated. it is useful to stand on the purpose of life, mechanical wind instruments. Using the object per ton of drops for the R134a / R1270 / R290 refrigerator (weight 50/5/45 weight) provides zero974 kW / TR, which is less than compared to R22 , R431A, R410A, R419A, R134a, R1270, R290 and fifteen refrigerator investigations include R134a, R290 and R1270. Thus, a higher system performance for a R134a / R1270 / R290 mixture (50/5/45 by weight percent). In general, a refrigerant mixture of R134a / R1270 / R290 (50/5/45 by weight percent) is a substituent in refrigerator maintenance instead of alternative environmental economics for the R22, including R431A, R410A, R419A and fifteen Mixed studies with the purpose of stand-alone COP, GWP and power consumption per ton of refrigeration equipment. Ahmed J. Hamad [22], This work presents associate experimental study to analyze the performance of vapour compression cooling system victimisation organic compound mixtures. A sub-cooling circuit and part extractor area unit integrated with main vapor compression cooling system and wont to predict the performance of organic compound mix R-290/R-600a as different refrigerant with 3 mass fractions of (60/40, 50/50 and 40/60) and compared with R-134a. The results showed that, the sweetening within the system performance was regarding Bastille Day increase in constant of performance, 6% increase in refrigeration impact and reduction proportion in freeze compartment temperature was in vary of twelve-tone music. Lower values of pressure quantitative relation and discharge temperature area unit detected for R-290/R-600a blends examination with R-134a. The reduction proportion in compressors power was in vary of Sep 11 throughout operation amount. It are often terminated that the organic compound refrigerants area unit associate economical, economically possible and setting friendly different refrigerants to R-134a in vapour compression cooling system with sub-cooling circuit. Organic compound refrigerants area unit ignitable, therefore, safety implications of victimisation such fluids might need specific system style . R. Cabello, E. Torrella and J. Navarro-Esbri [13], have analyzed the performance of a vapour compression refrigeration system using three different working fluids (R134a, R407c and R22). The operating variables are the evaporating pressure, condensing pressure and degree of superheating at the compressor inlet. They analyzed that the power consumption decreases when compression ratio increases with R22 than using the other working fluids.

B.O. Bolaji et al[14] investigated experimentally the performances of three ozone friendly Hydrofluorocarbon (HFC) refrigerants R12, R152a and R134a. R152a refrigerant found as a drop in replacement for R134a in vapour compression system.B.O. Bolaji[15] discussed the process of selecting environmental-friendly refrigerants that have zero ozone depletion potential and low global warming potential. R23 and R32 from methane derivatives and R152a, R143a, R134a and R125 from ethane derivatives are the emerging refrigerants that are non toxic, have low flammability and environmental-friendly. These refrigerants need theoretical and experimental analysis to investigate their performance in the system.James M. Calm [16], has studied the emission and environmental impacts of R11, R123, R134a due to leakage from centrifugal chiller system. He also investigated the total impact in form of TEWI and change in system efficiency or performance due to charge loss. He also summarized the methods to reduce the refrigerant losses by the system like design modifications, improvement in preventive maintenance techniques, use of purge system for refrigerant vapour recovery, servicing and lubricant changing in system.Samira Benhadid-Dib and Ahmed Benzaoui [17], have showed that the uses of halogenated refrigerants are harmful for environment and the use of "natural" refrigerants become a possible solution. Here natural refrigerants are used as an alternative solution to replace halogenated refrigerants. The solution to the environmental impacts of refrigerant gases by a gas which contains no chlorine no fluorine and does not reject any CO2 emissions in the atmosphere. The researchers

showed that emissions have bad effects on our environment. They also concerned by a contribution to the reduction of greenhouse gases and by the replacement of the polluting cooling fluids (HCFC).Eric Granryd [18], has enlisted the different hydrocarbons as working medium in refrigeration system. He studied the different safety standards related to these refrigerants. He showed the properties of hydrocarbons (i.e. no ODP and negligible GWP) that make them interesting refrigeratingalternatives for energy efficient and environmentally friendly. But safety precautions due to flammability must be seriously taken into account.Y. S. Lee and C. C. Su [19], have studied the performance of VCRS with isobutene and compare the results with R12 and R22. They used R600a about 150 g and set the refrigeration temperature about 4 °C and -10 °C to maintain the situation of cold storage and freezing applications. They used 0.7 mm internal diameter and 4 to 4.5 m length of capillary tube for cold storage applications and 0.6 mm internal diameter and 4.5 to 5 m length of capillary tube for freezing applications. They observed that the COP lies between 1.2 and 4.5 in cold storage applications and between 0.8 and 3.5 in freezing applications. They also observed that the system with two capillary tubes in parallel performs better in the cold storage and air conditioning applications, whereas that with a single tube is suitable in the freezing applications.

Mao-Gang He, Tie-Chen Li, Zhi-Gang Liu and Ying Zhang [20], have analyzed that the R152a/R125 mixture in the composition of 0.85 mass fraction of R152a has a similar refrigeration performance with the existing refrigerant R12.Experimental research on the main refrigeration performances of domestic refrigerators was conducted, under the different proportions and charge amounts, when R152a/R125 is used to substitute R12 as a ''drop-in'' refrigerant. The experimental results indicate that R152a/R125 can be used to replace R12 as a new generation refrigerant of domestic refrigerators, because of its well environmentally acceptable properties and its favorable refrigeration performances.

Ki-Jung Park, Taebeom Seo and Dongsoo Jung [21], have analyzed performances of two pure hydrocarbons and seven mixtures composed of propylene, propane, R152a, and dimethylether were measured to substitute for R22 in residential air-conditioners and heat pumps at the evaporation and condensation temperatures of 7 °C and 45 °C, respectively. Test results show that the coefficient of performance of these mixtures is up to 5.7% higher than that of R22. Whereas propane showed 11.5% reduction in capacity, most of the fluids had a similar capacity to that of R22. For these fluids, compressor-discharge temperatures were reduced by 11–17 °C. For all fluids tested, the amount of charge was reduced by up to 55% as compared to R22. Overall, these fluids provide good performances with reasonable energy savings without any environmental problem and thus can be used as long-term alternatives for residential air-conditioning and heat-pumping applications. A.Baskaran, and P.Koshy Mathews [22], A performance analysis on a vapour compression refrigeration system with various eco-friendly refrigerants of HFC152a, HFC32, HC290, HC1270, HC600a and RE170 were done and their results were compared with R134a as possible alternative replacement. The results showed that the alternative refrigerants investigated in the analysis RE170, R152a and R600a have a slightly higher performance coefficient (COP) than R134a for the condensation temperature of 50^0C and evaporating temperatures ranging between -30^0C and 10^0C.Refrigerant RE170 instead of R134a was found to be a replacement refrigerant among other alternatives.

Table 5. Comparison between R134a and R1234yf

	R134a	**Opteon®YF (R1234yf)**
Chemical name	1,1,1,2-tetrafluoroethane	2,3,3,3- tetrafluoropropene
Product group	Hydrofluorocarbo(HFC)	Hydrofluoroolefin(HFO)
Preferred oil	Poly Alkylene Glycol (PAG) (Polyolester (POE))	Poly Alkylene Glycol (PAG) formulated for R1234yf (Polyolester(POE))
ASHRAE safety classification	A1 – non-toxic & non-flammable	A2L – non-toxic & mildly-flammable
Boiling Point @ 1atm	-26°C	-29°C
Critical Temperature	102°C	95°C
Critical Pressure	41 bar(a)	34 bar(a)
ODP	0	0
GWP	1430	4
GWP as % of R134a	100%	0.3%

III. Conclusion

Researchers have carried out experimental investigations to find out the various factors affecting the performance of vapour compression refrigeration system. The following results were observed.

1. Working fluid properties, mixture proportions, suction and discharge pressure, dimensions of capillary tubes, amount of charge affect the performance of refrigeration system.
2. Single capillary tube having smaller inner diameter is suitable for freezing applications, whereas parallel capillary tubes having more inner diameter are suitable for cold storage or air conditioning applications.

3. For reducing the harmful effects on environment, it is necessary to use and research about the new refrigerants with low GWP and ODP.

Conflict of interest: The authors declare that there is no conflict of interests regarding the publication of this paper.

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