Performance of Eco-friendly Refrigerant Mixture in Vapour Compression Refrigeration System : A Review

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ABSTRACT

The present refrigeration and cooling businesses are moving towards chlorine and fluorine-free working liquids, as chlorine is one of the significant causative specialists for ozone layer consumption and fluorine is responsible for an Earth-wide temperature rise. R12, for the most part, acknowledged and more appropriate refrigerant for vapour compression refrigeration framework was eliminated by 1996 in created nations and must be eliminated by 2010 in agricultural nations because of its high ozone exhaustion potential and a dangerous atmospheric warming potential. R134a has been proposed as option of R12 in vapour compression refrigeration frameworks. Hydrofluorocarbons (HFCs) are more secure to ozone layer however it has high an Earth-wide temperature rise potential. Thus, the creation and utilization of R134a will be ended sooner rather than later. A huge number of refrigeration frameworks, heat pumps and climate control systems all around the world working with R12 and R134a must be retrofitted reasonably in case of the above phase out. This has inspired me to examine the exhibition of vapour compression refrigeration framework with a portion of the accessible climate amicable liquids as substitutes for R12 and R134a. Hydrocarbon refrigerants like propane, butane, isobutane, or different hydrocarbons are proposed as elective refrigerants to R12 and R134a because they have zero ODP and low GWP. They can't be utilized as immediate substitutes. Yet, on the off chance that a few hydrocarbons are blended, the combination, known as non-azeotropic refrigerant combinations (NARMS) can have properties like those of R12 and R134a.

Keywords: Hydrofluorocarbon refrigerant, GWP, ODP, Alternative refrigerants, Hydrocarbon refrigerants, Propane (R290), Isobutane (R600a).

INTRODUCTION

The utilization of refrigerator is normal and wide being used from one side of the planet to the other. Because of their amazing thermodynamic properties R12 and R134a were generally utilized as refrigerants for fridges.

R12 because of its high Ozone Depleting Potential (ODP) was eliminated by 2010 as per the Montreal Protocol, additionally the utilization of R134a must be diminished because of its high Global Warming Potential (GWP).

The ODP and GWP have become the main rules in the advancement of new refrigerants separated from the refrigerant CFCs because of their commitment to ozone layer consumption and an unnatural weather change.

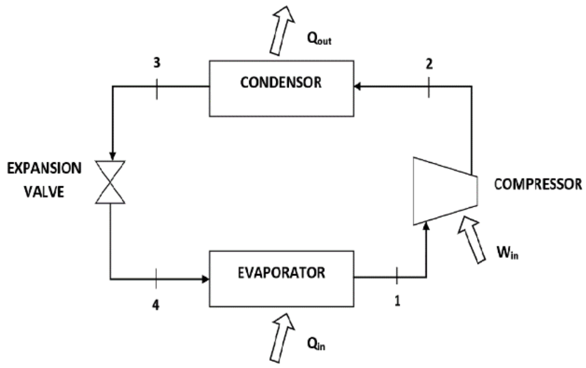

Figure 1 Schematic representation of simple VCR System

Montreal convention is identified with ODP, in 1987 Montreal convention set up the prerequisites that started the overall elimination of CFCs. Manufacturing of CFCs was eliminated by the Montreal Protocol in created nations in 1996 and in non-industrial nations in 2010. In 1992 Montreal convention set up the prerequisites that started the world – wide elimination of HCFCs. Complete manufacturing of HCFCs will be eliminated in 2030.

Kyoto convention is identified with GWP, Kyoto convention targets eliminating of substances that will prompt a worldwide temperature rise. R134a is utilized in domestic fridge and other vapour pressure frameworks as it was identified as a substitution to R12.

Hydrocarbon refrigerants are harmless to the ecosystem, non-poisonous, ozone friendly, lesser GWP and option for chlorofluorocarbons (CFCs), hydrochlorofluorocarbons (HCFCs) and hydrofluorocarbons (HFCs).

Table 1 ODP and GWP values of different refrigerants

Refrigerants		ODP	GWP(Time horizon of 100 years)
CFCs	R11 R12	1 1	4000 8500
HCFCs	R22	0.055	1700
HFCs	R134a R404a R410a	0 0 0	1300 3800 2000
Natural refrigerants	R717 (NH_3) R290 R600a	0 0 0	<1 3 3

Ecofriendly refrigerants

Non-azeotropic (zeotropic) mixes of refrigerants are genuinely being considered as substitutions for ecologically harming unadulterated refrigerants. By blending a few parts appropriately, vapour compression like that of R12 and R134a can be acquired without ecological issues. The zeotropic refrigerant combinations have been displayed to expand the coefficient of performance of refrigeration frameworks under legitimate working conditions. Hydrocarbon liquids are by and large thought to be naturally benevolent. The most well-known hydrocarbons that satisfy the prerequisites of the cooling innovation are propane (R-290), propylene (R-1270), and mixes with propane and butane (R-600) or isobutane (R-600a). Hydrocarbons have great thermodynamic properties and as they structure a group of liquids, there can be an acceptable choice over a somewhat more extensive scope of use temperatures.

Hydrocarbon refrigerants have low poisonousness, high miscibility with mineral oil, and great material similarity. They additionally have great ecological properties with zero ODP and very low GWP. The significant downside with HCs is their combustibility. Be that as it may, it is very conceivable to utilize HCs securely in refrigeration and cooling frameworks. In many coolers, a hermetic compressor is utilized and the entire framework is subsequently totally sealed. Likewise, refrigerant charge is diminished due to hydrocarbon's higher specific volume of fluid when contrasted with conventional refrigerants.

After the CFCs and HCFCs were considered unsuitable as working liquids in refrigeration, cooling, and heat pump applications, there has been a renaissance for carbon dioxide innovation moreover. CO_2 is one of only a handful of exceptional normal refrigerants, which is neither combustible nor harmful. It is modest, broadly accessible, and doesn't influence the worldwide climate as numerous different refrigerants. CO_2 has a GWP worth of 1. Carbon dioxide is a brilliant alternative refrigerant among the normal refrigerants, particularly in applications where the harmfulness and combustibility of ammonia and hydrocarbons might be an issue. The working pressing factor range is high. Parts for a lot higher plan pressures are required, regularly 150 bar maximum working pressing factor. In this way, it requires a robust design to expand the initial expense and risk of exploding.

LITERATURE REVIEW

Since this examination has been centred around retrofitting of existing R12 and R134a frameworks with elective refrigerants, an itemized writing study identified with the exhibition of HFCs, HCs and their combinations in refrigeration, heat pump and cooling frameworks has been made.

Lorentzen [1] played out an examination with ammonia and water and summed up the merits of R717. The benefits are that, they have a lower molecular weight, wide scope of working temperature in light of its high critical point, high latent heat of vapourization and simple leak detection. Among the refrigerants that were explored, water (R718) had a much higher COP than R717 at higher evaporator temperatures. In any case, R717 had a few drawbacks, particularly when human health, safety and material thought are considered.

Kim et al [2] led a test on heat pump with two azeotropic refrigerant combinations of R134a/R290 and R134a and R600a. Their trials demonstrated that the COP of R134a/R290 was lower than that of R22 and R290. In any case, R134a and R600a showed higher COP than that of R12 and R134a. The discharge temperature of R134a/R290 was observed to be lower than that of R22 and somewhat higher than that of R290. For R134a and R600a blend, the discharge temperature was lower than that of R12.

Richardson and Butterworth [3] have explored the performance of propane and two propane/isobutane combination as option in contrast to R12 refrigerant in an unmodified airtight vapour compression framework. It has been accounted for that the hydrocarbon combination with 56% propane and 44% isobutane has a COP more prominent than that of R12 all through the scope of temperatures explored. The 43%/57% hydrocarbon combination just accomplishes a superior COP at temperatures above about - 10°C. It has likewise been accounted for that the COP increments with the extent of propane is expanded.

Dongsoo Jung et al [4] have examined the presentation of R290/R600a combination in domestic coolers as option in contrast to R12. It has been accounted for that the blend for 0.6 mass portion of R290 showed a 3% to 4% expansion in energy efficiency and a quicker cooling rate when contrasted with R12.

Hammed and Alsaad [5] have researched the presentation of domestic fridge with four proportions of propane, butane and isobutane. The HC combination with half propane, 38.3% butane and 11.7% isobutane showed the best presentation. This blend at the evaporator temperature of - 16˚C and condenser temperature of 27˚C gave a COP of 3.7 when contrasted with COP of 3.6 for R12 at a similar temperature.

Chang et al [6] have explored tentatively the presentation of single hydrocarbon refrigerants and binary combinations of propane/isobutane and propane/butane in a heat pump framework with two chambers open reciprocating type compressors. It has been accounted for that when zeotropic refrigerant combinations of R290/R600a and R290/R600 are utilized, the cooling and heating limit increments regarding mass proportion of R290. It has likewise been accounted for that the COP of hydrocarbon blends for the cooling condition is higher than that of R22 for a wide scope of the mixture combinations.

Lee Su et al [7] played out a trial investigation on the exhibition of R600a in a domestic fridge. It was seen that the COP estimated for the chilled storage application ranged between 1.2 to 4.5 and for freezing application between 0.8 to 3.5 which was equivalent to the refrigeration framework working with the refrigerants R12 and R22.

Tashtoush et al [8] led an experimental examination on the exhibition of a domestic cooler working with butane/propane/R134a blend as a refrigerant to track down an option in contrast to R12. They found that blend with 25g butane/25g propane and 30g R134a gave results nearer to R12. At 100 W the COP of this combination was 5.4% not exactly that of R12 and at 350W it was 0.8% under R12.

Bilal and Said [9] have directed an exploratory examination to consider the exhibition of LPG with the combination of about 30% propane, 55% n-butane and 15% iso-butane as an option in contrast to R12 in domestic fridges. It has been accounted for that the cooling limit and specific compressor work are higher than that of R12 and the COP values are equivalent with that of R12 for a mass charge of 80g.

Jabaraj and Mohanlal [10] presumed that the R-407C/HC blend could be an ozone amicable, energy productive, safe and financially reasonable option in contrast to R-22 for window cooling frameworks. The way that POE oil can be apportioned with by utilizing R-407C/HC blend in the spot of R-407C is a huge finding in this work. It is accepted that this blend could be a comfort to the air conditioning area that is tested with the states of Montreal Protocol to eliminate R-22.

Somchai Wongwises et al [11] utilized combinations of propane, butane and iso-butane blended in four distinct proportions in an automotive air cooling framework dealing with R134a to track down an appropriate substitute for R134a. They found that among all the combination with various proportions, the ternary blend including 50% propane, 40% butane and 10% isobutane yielded the highest COP, which was 17% higher than R134a, while the compressor power utilization was higher by 21% and the refrigeration capacity expanded by 41% contrasted with R134a.

Senthilkumar et al [12] directed a performance test on R123/R290 (70/30) refrigerant combination to track down an option in contrast to R12. At all evaporator conditions considered, the COP and overall performance of the blend was observed to be more than that of R12. It was likewise seen that the temperature and pressure ratio variety of the blend was like that of R12, thus no changes in the R12 framework were required.

Mani and Selladurai [13] performed experiments using a vapour compression refrigeration system with the new R290/R600a refrigerant mixture as a substitute refrigerant for R12 and R134a. According to the results of their experiments, the refrigerant R290/R600a had a refrigerating capacity 19.9% to 50.1% higher than that of R12 and 28.6% to 87.2% than that of R134a. The R290/R600a blend's performance coefficient (COP) is improved by 3.9-25.1% compared to that of R12 at lower evaporating temperatures and by 11.8–17.6% at higher evaporating temperatures. The refrigerant R134a had a slightly lower coefficient of performance (COP) than R12.

Srinivas et al [14] investigated five different combinations of R134a/R290/R600a and concluded that the ternary combination of (25%R134a/37.5%R290/37.5%R600a) is by all accounts a suitable long-haul elective for R134a from the perspective of eco-friendly refrigerant combination with zero ODP, low GWP and high energy effective, requiring negligible changes in the current coolers.

Lovelin Jerald and Senthil Kumaran [15] carried out the work to dissect and think about the different thermo actual properties of drop in refrigerants: R134a, R404a and R600a with R12 refrigerants with various tube bore around of 0.30-inch, 0.30 inch (twofold), 0.036-inch, 0.044 inch and 0.50 inch for a length of 10 m.

A Baskaran and Koshy Mathews [16] investigated the alternative chosen refrigerants R152a and an azeotropic combination of R152a/R600a which appears to be a fitting long-haul elective for R134a from the perspective of eco-friendly refrigerant combination with zero ODP, low GWP and high energy proficient, requiring negligible changes in the current fridges. Test examinations were done on a domestic fridge with the above selected elective refrigerants and the benchmark tests were directed with R134a. The performance boundaries like draw down time, energy utilization of the compressor, refrigeration impact, COP, compressor discharge temperature and so on, were examined and contrasted with the base refrigerant.

SP Arunkumar and Koshy Mathews [17] seen that the hydrocarbon mixtures of R290/R600, R290/R600a and LPG is found be a suitable option in contrast to R134a in a vapour compression refrigeration framework. During the exergy investigation, it was tracked down that the condenser and evaporator temperatures effectively affect COP and the exergy proficiency of the framework

Lalitha Saravanan and Mohan Lal [18] proposed low GWP HC290 refrigerant that utilized as an option in contrast to HCFC22 with shrewd improvement in case of eliminate on existing forced air systems, just as for new frameworks. In existing frameworks, minimization of refrigerant charge can be accomplished by part level changes. Consequently, HC290 is a superior substitute for changing over existing HCFC22 forced air system and can be productively utilized in new frameworks additionally with least charge amount.

Karthikeyan et al [19] investigated and concluded that the VCR automobile air conditioning framework working with hydrocarbon refrigerant R600a (Isobutane [2-methylpropane]) as working liquid in the consolidating pressure around 7 bar, furthermore, COP going from 2.08 to 2.5 could be the best option for all the working states of the framework examined.

Elumalai and Vijayan [20] experimented on a window air conditioning system with the five chosen refrigerant blends and the effect of the new combinations were examined. The helpful exhibition boundaries, for example, coefficient of performance, compressor power, refrigeration effect, mass stream rate, compressor discharge temperature and pressure ratio and so forth, were examined and compared with the base refrigerant R22. The structure assigned as Mix 3 has given better execution among the five chose elective blends.

The literature review introduced gives a thought regarding the different optional refrigerants accessible to retrofit the conventional frameworks with its own benefits and disadvantages. In the subsequent segments the point-by-point writing study given gives the approaches to track down a new eco-friendly elective refrigerant blend to be utilized in a vapour compression refrigeration framework to work on the performance.

CONCLUSION

From the above literature study, it is tracked down that, the few refrigerants are eliminated because of their effect on nature, and are expected to be replaced. Barely any specialists have investigated blend of various refrigerants in refrigeration framework. Henceforth, it is clear that there is wide extension to do the examination in the investigation on various sorts of refrigerants used to further develop execution of domestic cooler.

R12 is a CFC refrigerant and R134a is a HFC refrigerant and it adds to worldwide warming in light of fluorine content in it. Ozone consumption also, absolute environmental change relies upon both a worldwide temperature alteration potential and ozone depletion potential. In this way, there is a need to discover options of R12 and R134a under Kyoto convention and Montreal convention.

Following results were seen from this survey paper:

1. A lot of working liquids have been tried for use in coolers or in heat pumps. The hydrocarbon combinations gives better performance over that of R12 and R134a.

2. The hydrocarbon combinations have vapour pressure close to or lower than that of R12 and R134a.

3. The charge amount of hydrocarbon refrigerant mixture combination is less than that of R12 and R134a due to their lower fluid densities.

4. The latent heat of hydrocarbon refrigerant mixture combination is higher than that of R12 and R134a and in this way these hydrocarbon combinations will give higher refrigerating capacity.

5. The fluid viscosity of hydrocarbon refrigerant mixture combination is lower than that of R12 and R134a refrigerants.

There is a need of contrasting the elective refrigerants from thermodynamic, thermo monetary, natural, harmfulness, soundness and combustibility perspective. In this way, that best option in contrast to R12 and R134a can be discovered.

According to Montreal and Kyoto conventions R600a, R290 and mixes of R290 and R600a are the better choice for the substitution of R12 and R134a in domestic fridge, due to their low worldwide warming potential (Global Warming Potential) and zero ozone depletion potential(ODP).

There is a need of additional examination to be done on the various combinations of HCs, to discover the other options of R134a.

Based on the above review, it is observed that the hydrocarbon blends are found to be a viable alternative to R134a and R12 in a vapour compression refrigeration framework.

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