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A Review on Refrigerants, And Effects on Global Warming For Making Green Environment

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Abstract: *Refrigerant is the fluid used for heat transfer in a refrigerating system that absorbs heat during evaporation from the region of low temperature and pressure, and releases heat during condensation at a region of higher temperature and pressure."This heat transfer generally takes place through a phase change of the refrigerant. This research studies various refrigerants used in the refrigeration system along with their effects on the environment, effects on global warming.*
Keywords: *Refrigerants, Global warming, chlorofluorocarbons, hydro fluorocarbons*

I. Introduction

Refrigeration goes back to ancient times using stored ice, vaporization of water, and other evaporative processes. Numerous investigators in different countries studied phase change physics in the 1600s and 1700s; their fundamental findings set the foundation for ‘‘artificial’’ (man-made) refrigeration. Oliver Evans first proposed the use of a volatile fluid in a closed cycle to freeze water into ice (Evans, 1805). He described a system that produced refrigeration by evaporating ether under a vacuum, and then pumped the vapor to a water-cooled heat exchanger to condense for re-use. While there is no record that he built a working machine, his ideas probably influenced both Jacob Perkins and Richard Trevithick.

Since the first vapour compression refrigeration system was made by Jacob Parkin in 1834, a large number of chemical substances have been tried and tested as working fluids or refrigerants. Starting from ethyl chloride, ammonia, carbon dioxide, sulphur dioxide, methyl chloride, propane, iso-butane and water, the industry developed gradually, but a great breakthrough occurred with the invention of the dichloroflouromethane substances in 1930 by Thomas Midgley and Albert Henne and by then, the family of chemicals that included chlorofluorocarbons (CFCs) and hydro fluorocarbons (HCFCs) became the most dominant types of refrigerants, due to their properties of non-toxicity, non-flammability, non-corrosiveness and non-irritability.

But the problems occurred when in 1974, Molina and Rowland, reported and published their ozone depletion hypothesis in which they claimed that the chlorine element catalytically destroyed the ozone layer in the stratosphere. In addition it was also found that these refrigerants were significant greenhouse gases.

This review report eventually set grounds for the phase out of chlorofluorocarbons and hydro chlorofluorocarbons (through Montreal protocol) which contained chlorine atoms. The research then began with the hydro fluorocarbons, which were chlorine free compounds, but the major concern was their relative global warming potential that paved way for letting their phase-out in the near future and boosted up the research for their suitable alternatives, which is seen in the form of hydrocarbons and their mixtures. In spite of the issues regarding their flammability, hydrocarbons are being seen as the potential alternatives to CFCs, HCFCs, HFCs and their mixtures on grounds of their cost, availability and coefficient of performance.

II. Literature Survey

1. The paper presented by S. B. Riffat, C. F. Afonso, A. C. Oliveirat and D. A. Reay under the title of **"Natural refrigerants for refrigeration and air-conditioning systems"** is a review of the application of the main natural refrigerants, for refrigeration and air-conditioning systems, as an alternative to synthetic new refrigerants (HFCs) by considering recent research and development in this area. Following items were identified as conclusion of this paper [1]:

- Future research in vapour compression ammonia systems should focus on low charge in large-capacity systems, as well as small units;
- For absorption ammonia or water systems to be competitive, higher efficiencies and lower system sizes would be desirable; rotary equipment and vapour recompression systems are a first, tentative step in that direction;
- Due to their flammability, the main research on hydrocarbons has been focused on low charge in large-capacity systems;

- The use of carbon dioxide depends on the development of main system components (compressors, evaporators, gas coolers and control devices) which are suitable for trans-critical cycles;
- Water vapour compression cycles have been used for high-temperature applications (above 100°C); the feasibility of lower-temperature applications depends on research in axial or centrifugal compressors;
- The air refrigeration cycle is attractive at lower (negative) temperatures; however, further research is to be done regarding more efficient rotary compressors and expanders.

2. The experimental study carried out by M.A. Alsaad , M.A. Hammad under the title of **"The application of propane/butane mixture for domestic refrigerators"** determine the performance of a domestic refrigerator when a propane/butane mixture called liquefied petroleum gas (LPG) which is locally available and comprises 24.4% propane, 56.4% butane and 17.2% iso-butane is used as a possible replacement to the traditional refrigerant CFC 12 as the use of LPG as a replacement refrigerant can contribute to the solution of ozone depletion problem and global warming potential [2].

The refrigerator used in the present study is of medium size with a gross capacity of 320ltr and is designed to work on CFC 12. The performance parameters investigated are the refrigeration capacity, the compressor power and the coefficient of performance (COP). It was found that the refrigerator worked efficiently when LPG was used as refrigerant instead of CFC 12. The evaporator temperature reached -15°C with COP value of 3.4 against 3.45, obtained from R12, at a condenser temperature of 27°C and an ambient temperature of 20°C. The results of the present work indicated the successful use of this propane/butane mixture as an alternative refrigerant to CFC 12 in domestic refrigerators.

3. This paper presents an experimental study carried out by M.A. Hammad, M.A. Alsaad under the title of **"The use of hydrocarbon mixtures as refrigerants in domestic refrigerator" [3]**, for evaluating the performance parameters of a domestic refrigerator when four ratios of propane, butane and iso butane:-

100% propane,
75% propane-19.1% butane-5.9% iso butane,
50% propane-38.3% butane-11.7% iso butane and
25% propane-57.5% butane-17.5% iso butane

Are used as possible alternative replacements to the traditional R-12 refrigerant. The proposed alternative refrigerants have the advantage of being locally available, cheap and of an environmentally friendly nature. The parameters investigated were the evaporator capacity, the compressor power, the coefficient of performance (COP) and the cooling rate characteristics. The work showed that the hydrocarbon mixture with 50% propane-38.3% butane-11.7% iso-butane is the most suitable alternative refrigerant with the best performance among all other hydrocarbon mixtures investigated. When this hydrocarbon mixture was used the evaporator temperature reached -16°C with COP of 3.7 at condenser temperature of 27°C as compared to COP of 3.6 for the traditional R-12 refrigerant at the same temperatures. The refrigerator worked satisfactorily with the proposed alternative refrigerant without the need for any modification or adjustment.

4. In this work an experimental investigation was carried out by E. Halimic, D. Ross, B. Agnew, A. Anderson, and I. Potts under the title of **"A comparison of the operating performance of alternative refrigerants"**, to compare the operating performance of three alternative refrigerants-R401a, R290 and R134a with R12 for use in a vapour compression refrigeration cycle on the basis of refrigeration capacity and COP [4].

The results indicated that the cooling capacity of R290 (propane) was the largest of the refrigerants tested, and higher than the original refrigerant R12. Also the COP of R290 was found to be very similar to that of R12. Thus it can be said that it represents an attractive alternative to existing CFCs in small domestic refrigerators, when subjected to correct technical application of operational and safety factors. If this refrigerant was to be used in original equipment, it would require a smaller capacity compressor than would R12. Also it was found that the performance of R134a is very similar to that of R12 justifying the claim that it is a drop in replacement for R12 but of the refrigerants tested it gave the poorest performance.

Thus when viewed in terms of green house impact, COP and cooling effect R290 showed the best performance.

5. In this work an experimental analysis had been carried out by S. Joseph Sekhar, D. Mohan Lal and S. Renganarayanan under the title of **"Improved energy efficiency for CFC domestic refrigerators retrofitted with ozone-friendly HFC134a/HC refrigerant mixture"** in a 165 l CFC12 household refrigerator retrofitted with eco-friendly refrigerant mixture of HFC134a/HC290/HC600a without changing the mineral oil [5]. Their performance, as well as energy consumption, were compared with the conventional one and it was concluded that mixture M09 (containing 9% HC blend by weight in the HFC134a) is the most promising alternative to conventional CFC12 system on the following bases:-

- Energy consumption is reduced by 4.8 to 6.4%.

- The system has been running successfully for more than 12 months, thus it is evident that the new mixture is compatible with mineral oil
- The improvement in theoretical COP and actual COP are 3 to 12% and 3 to 8% respectively.
- The temperature glide due to zeotropic nature of the refrigerant mixture is well within the acceptable limit of 3°C.
- As during the tests, none of the existing components were replaced/ modified and hence household refrigerator can be retrofitted with M09 mixture.

6. In this experiment conducted by **Somchai Wongwises, Nares Chimres** under the title "**Experimental study of hydrocarbon mixtures to replace HFC-134a in a domestic refrigerator**", a refrigerator designed to work with HFC-134a with a gross capacity of 239 l is used [6]. The consumed energy, compressor power, refrigerant temperature and pressure at the inlet and outlet of the compressor as well as the distributions of temperature at various positions in the refrigerator are recorded and analyzed. The refrigerant mixtures used are divided into three groups:

- The mixture of three hydrocarbons: **-** It consist of mixture of the three hydrocarbons (propane/isobutene/butane) in the ratio of 75/25/5, 100/0/0 and 50/40/10.
- The mixture of two hydrocarbons:-it consist of propane/ butane and propane/iso-butane I the ratio of 60/40.
- The mixture of two hydrocarbons (either propane/butane 'or' propane/iso-butane) in the ratio of 40/30 and rest HFC-134a.

In this way three groups of hydrocarbon mixtures were experimented and the best alternative mixture of HFC-134a in each group was selected. Overall the conclusion drawn showed that the propane/butane 60%/40% is the most appropriate alternative refrigerant to HFC-134a.

7. In this experiment, M. Fatouh , M. El Kafafy under the title of **"Experimental evaluation of a domestic refrigerator working with LPG"** have tested Liquefied petroleum gas (LPG) of 60% propane and 40% commercial butane for being used as a drop-in substitute for R134a in a single evaporator domestic refrigerator with a total volume of 10 ft^3 (0.283 m^3) [7].

Continuous running and cycling tests were performed on that refrigerator under tropical conditions using different capillary tube lengths and various charges of R134a and LPG yielded results that the lowest electric energy consumption was achieved with combination of capillary tube length of 5 m and charge of 60 g. This combination achieved higher volumetric cooling capacity and lower freezer air temperature compared to R134a. Higher actual COP, lower on-time ratio and lower energy consumption of LPG refrigerator by nearly 7.6%, 14.3% and 10.8%, respectively, compared to those of R134a refrigerator were achieved. In conclusion, the proposed LPG seems to be an appropriate long-term candidate to replace R134a in the existing refrigerator, except capillary tube length and initial charge.

8. In the present work done by M. Fatouh , M. El Kafafy under the title of **"Assessment of propane/commercial butane mixtures as possible alternatives to R134a in domestic refrigerators",** the possibility of using hydrocarbon mixtures as working fluids to replace R134a in domestic refrigerators has been evaluated through a simulation analysis. The performance characteristics of the considered domestic refrigerator were identified by the coefficient of performance (COP), volumetric cooling capacity, cooling capacity, condenser capacity and input power to compressor, discharge temperature, pressure ratio and refrigerant mass flow rate over a wide range of evaporation temperatures (-35 to -10°C) and condensation temperatures (40–60°C) for various working fluids [8].

This simulation aimed at comparing the performance characteristics of the domestic refrigerator working with R134a, commercial butane, propane and propane/iso-butane/n-butane mixtures with different concentrations of propane under various operating conditions.
The results showed that pure propane could not be used as a drop in replacement for R134a in domestic refrigerators because of its high operating pressures and low COP. Commercial butane yields many desirable characteristics but requires a compressor change. And finally for various mixtures, the reported results confirmed that the propane/iso-butane/n-butane mixture with 60% propane is the best drop in replacement for R134a in domestic refrigerators under normal, subtropical and tropical operating conditions.

9. In the present work, an experimental investigation has been made by M. Mohanraj, S. Jayaraj, C. Muraleedharan , P. Chandrasekar under the title of **"Experimental investigation of R290/R600a mixture as an alternative to R134a in a domestic refrigerator"** with hydrocarbon refrigerant mixture (composed of R290 and R600a in the ratio of 45.2:54.8 by weight) as an alternative to R134a in a 200 l single evaporator domestic refrigerator [9].

Continuous running tests were performed under different ambient temperatures (24, 28, 32, 38 and 43 ◦C), while cycling running (ON/OFF) tests were carried out only at 32 ◦C ambient temperature. The results showed that the hydrocarbon mixture has lower values of energy consumption; pull down time and ON time ratio by about 11.1%, 11.6% and 13.2%, respectively, with 3.25–3.6% higher coefficient of performance (COP). The discharge temperature of hydrocarbon mixture was found to be 8.5 to 13.4 K lower than that of R134a.
Also about 50% reduction in quantity of charge is seen by replacing R134a by HCM, i.e., from 120gm to 60gm. Also the miscibility of HCM with POE was found to be good.
The overall performance has proved that he above hydrocarbon refrigerant mixture could be the best long term alternative to phase out R134a.

10. In this paper a theoretical performance study is done by A.S. Dalkilic and S. Wongwises under the title of **"A performance comparison of vapour-compression refrigeration system using various alternative refrigerants",** on a traditional vapour-compression refrigeration system with refrigerant mixtures based on HFC134a, HFC152a, HFC32, HC290, HC1270, HC600, and HC600a for various ratios and their results were compared with CFC12, CFC22, and HFC134a as possible alternative replacements [10].

Theoretical results showed that all of the alternative refrigerants investigated in the analysis have a slightly lower performance coefficient (COP) than CFC12, CFC22, and HFC134a for the condensation temperature of 50 °C and evaporating temperatures ranging between −30 °C and 10 °C. Refrigerant blends of HC290/HC600a (40/ 60 by wt. %) instead of CFC12 and HC290/HC1270 (20/80 by wt. %) instead of CFC22 are found to be replacement refrigerants among other alternatives in this paper as a result of the analysis.
Considering the comparison of performance coefficients (COP) and pressure ratios of the tested refrigerants and also the main environmental impacts of ozone layer depletion and global warming, refrigerant blends of HC290/HC600a (40/60 by wt.%) and HC290/HC1270 (20/80 by wt.%) are found to be the most suitable alternatives among refrigerants tested for R12 and R22 respectively. The refrigeration efficiency, the performance coefficient (COP) of the system, increases with increasing evaporating temperature for a constant condensing temperature in the analysis.

III. Conclusion

This research review the various refrigerants and their properties. In first phase, this review report thoroughly study chlorofluorocarbons and hydro chlorofluorocarbons (through Montreal protocol) which contained chlorine atoms. In the second phase, research began with the hydro fluorocarbons, which were chlorine free compounds, as well as the effects of their potential on global warming, that paved way for letting their phase-out in the near future and boosted up the research for their suitable alternatives, which is seen in the form of hydrocarbons and their mixtures.

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