A REVIEW ON ALTERNATIVE REFRIGERANT FOR VCR SYSTEM

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ABSTRACT

Refrigeration is a process of removing heat from an enclosed space or from a substance for the purpose of lowering the temperature. The substance use for that purpose is called refrigerant.The most commonly used refrigeration system among all refrigeration system is vapour compression refrigeration system. For most of the states the problems of forming and maintaining the earth's ozone layer & minimize global warming at the planetary level via the greenhouse effect, represents a major priority. So, According to Montreal and Kyoto protocols R12 is already phase out. R134a is the most commonly used refrigerant in the domestic refrigeration due to its excellent thermodynamic properties. But because of its high global warming potential, it will phase out in the recent years. So it is time to introduce new refrigerant which have low global warming potential for the domestic refrigerators. Performance of VCR system can be improved by using proper refrigerant. Environmentally preferred refrigerants have low or zero ODP, relatively short atmospheric lifetimes, low GWP, ability to provide good system efficiency, appropriate safety properties. This paper presents a review on recent development of possible substitutes for non-ecological refrigerants because the use of ecological refrigerants plays a crucial role for reducing the environmental impacts of the halogenated refrigerants to protect the environment.

Keyword: - *Vapour compression systems, Refrigerants, Ecological substitutes*

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1. INTRODUCTION

The earliest refrigeration systems were based on vapour compression cycles & used ethyl ether as refrigerant. In 1869, changes were made in system to use ammonia as refrigerant. It rules over the field for well over 60 years. Sulphur dioxide, methyl chloride, carbon dioxide came into use as refrigerant in vapour compression cycle refrigeration machine. Most of that refrigerant material has been discarded for safety reason or for lack of chemical or thermal stability. In the present days, many new refrigerants including halo-carbon compounds, hydro-carbon compounds are used for air conditioning & refrigeration application.

Refrigerant blends are mixtures of refrigerants that have been formulated to provide a match to certain properties of the refrigerants originally used. These blends have been researched and developed since the issue of the ODP phase-out emerged and are being produced by many chemical companies. Blends can have 2-3 or even 4 components, and can have a major component of a HCFC, HFC or HC; in most cases they will consist of a combination of these Refrigerants. The refrigerant blends have their own trade names. The well-known ASHRAE (American Society of Heating, Refrigerating and Air Conditioning Engineers) refrigerant number applies to blends.

There are different types of refrigerant blend like Hydrocarbon (HC) blends, HFC-based blends, HCFC-based blends, CARBON DIOXIDE-based blends, AMMONIA-based blends.

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2. LITRETURE REVIEW

Mohamed El-Morsi [1] presents a comparison of energetic and exergetic performance of a vapour compression refrigeration system using pure HC (hydrocarbon) refrigerants. In this study, three different pure HC propane (R290), butane (R600) and commercial LPG (liquefied petroleum gas) are used in the theoretical analysis. R134a is also used in the analysis as a reference refrigerant. The evaporator temperature ranges from -30 to 0℃ while the condenser ranges from 30 to 50℃. MATLAB software is used for solving the thermodynamic equations, while the thermo-physical properties are calculated using REFPROP software. The results show that R600 has the highest COP and exergetic efficiency, while LPG has the lowest. When compared to R134a, the COP for R134a is higher than that for LPG by 10%. Also, the exergetic efficiency is higher by 5%.

M. Mohan raj [2] studies the energy performance of a domestic refrigerator with R134a and R430A as alternative refrigerant. The performance has been assessed for three different condensing temperatures, specifically, 40, 50 and 60 °C with a wide range of evaporator temperatures between −30 and 0 °C. The performance of the domestic refrigerator was compared in terms of volumetric cooling capacity, coefficient of performance, compressor power consumption and compressor discharge temperature. Total equivalent global warming impact of the refrigerator was assessed for a 15-year life time. The results showed that volumetric cooling capacities of R430A and R134a are similar, so that R134a compressor can be used for R430A without modifications. The coefficient of performance of R430A was found to be higher than that of R134a by about 2.6–7.5% with 1–9% lower compressor power consumption at all operating temperatures. The compressor discharge temperature of R430A was observed to be 3–10 °C higher than that of R134a. Total equivalent global warming impact of R430Awas found to be lower than that of R134a by about 7% due to its higher energy efficiency. The results confirmed that R430A is an energy efficient and environment-friendly alternative to R134a in domestic refrigerators.

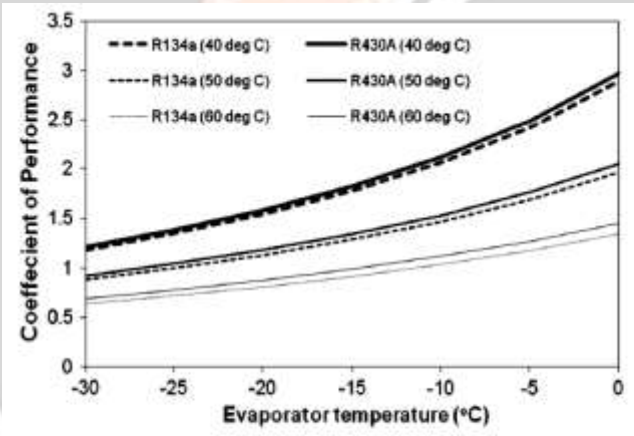

Fig.1.Effect of evaporator temperature on COP for different condenser temperature [2]

M. Fatouh et al. [3] studies Experimental evaluation of a domestic refrigerator working with LPG. Liquefied petroleum gas (LPG) of 60% propane and 40% commercial butane has been tested as a drop-in substitute for R134a in a single evaporator domestic refrigerator. Experimental results of the refrigerator using LPG of 60 g and capillary tube length of 5 m were compared with those using R134a of 100 g and capillary tube length of 4 m. Result shows that Pull-down time, pressure ratio and power consumption of LPG refrigerator were lower than those of R134a refrigerator by about 7.6%, 5.5% and 4.3%, respectively. Also, actual COP of LPG refrigerator was higher than that of R134a by about 7.6%. Lower on-time ratio and energy consumption of LPG refrigerator by nearly 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

B.O.Bolaji [4] presents an experimental study of R152a and R32, environment-friendly refrigerants with zero ozone depletion potential and low global warming potential, to replace R134a in domestic refrigerator. A refrigerator designed and developed to work with R134a was tested, and its performance using R152a and R32 was evaluated and compared with its performance when R134a was used. The results obtained showed that the design temperature and pull-down time set by International Standard Organization for small refrigerator were achieved earlier using refrigerant R152a and R134a than using R32. Result show that the average COP obtained using R152a is 4.7% higher than that of R134a while average COP of R32 is 8.5% lower than that of R134a.

The system consumed less energy when R152a was used. The performance of R152a in the domestic refrigerator was constantly better than those of R134a and R32 throughout all the operating conditions, which shows that R152a can be used as replacement for R134a in domestic refrigerator.

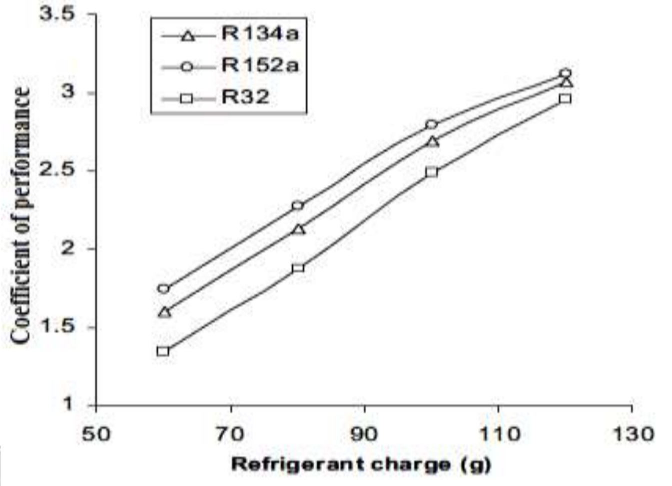

Fig.2.Effect of refrigerant charge on COP for different refrigerant [4]

K. Mani [5] studies experimental performance of a vapour compression refrigeration system with the new R290/R600a refrigerant mixture as drop-in replacement. The result compared with CFC12 and HFC134a. The vapour compression refrigeration system was initially designed to operate with R12. Experimental results showed that the refrigerant R290/R600a had 19.9% to 50.1% higher refrigerating capacity than R12 and 28.6% to 87.2% than R134a.The refrigerant R134a showed slightly lower refrigerating capacity than R12. The mixture R290/R600a consumed 6.8% to 17.4% more energy than R12. The refrigerant R12 consumed slightly more energy than R134a at higher evaporating temperatures. The coefficient performance of R290/R600a mixture increases from 3.9% to 25.1% than R12 at lower evaporating temperatures and 11.8% to 17.6% at higher evaporating temperatures. The refrigerant R134a showed slightly lower coefficient of performance 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 CFC12 and HFC134a.

Adrian Mota-Babiloniet al. [6] studies Experimental evaluation of R448A as R404A lower-GWP alternative in refrigeration systems. The experimental tests are intended to simulate typical freezing and conservation temperatures and different condensing conditions Due to the adoption of EU Regulation No 517/2014, R404A is going to be banned in Europe in most of refrigeration applications, in which is typically used, due to its very high GWP value, 3943.R448A is a non-azeotropic mixture of R32 (26%), R125 (26%), R1234yf (20%), R134a (21%) and R1234ze (E) (7%). It is selected as R404A alternative because of its similar properties that ensures good adaptation to existing systems.R448A volumetric efficiency is lower than that of R404A. Result shows that If the same compression ratio is considered for both refrigerants, volumetric efficiency of R448A is between 5% and 7% below that resulting for R404A. R448A refrigerating effect is between 35% and 50% greater than for R404A at low evaporation conditions and between 30% and 40% at higher evaporating temperatures. R448A COP is above that of R404A for all conditions considered. Specifically, the increase is from 13% to 21% at 240 K and from 6% to 15% at 265 K. R448A also can be considered as an environmental friendly and safe alternative in smaller commercial refrigeration applications because it does not presents problems associated to flammability.

S.J. Sekhar et al. [7] studies HFC134a/HC600a/HC290 mixture a retrofit for CFC12 systems.. Even though HFC134a and HC blend containing 55.2% HC600a and 44.8% HC290 by weight have been reported to be substitutes for CFC12, they have their own drawbacks in respect of energy efficiency/flammability/serviceability aspects of the system. In this present work, experimental investigation has been carried out on the performance of an ozone friendly refrigerant mixture containing HFC134a/HC blend in two low temperature systems a 165 l domestic refrigerator and a 400 L deep freezer. The refrigerant mixtures considered are M07, M09 and M11.The better refrigerating effect of M09 resulted in 10% shorter pull down time in domestic refrigerator. The actual COP of the system is improved by 5–17% in low temperature systems. The capillary optimization tests proved that the standard capillary used in CFC12 systems can be used for the mixture also. But when the thermostatic expansion valves are used suitable super heat adjustment is required. The actual refrigeration effect of M09 is 7 -26.5% and higher than that of CFC12 in domestic refrigerator. TheM09 mixture reduces the per day consumption by 4.1–7.6%in domestic refrigerator. The discharge temperature of the compressor is reduced by the M09. Hence, it could improve the compressor life.

T.S. Ravikumar et al. [8] studies On-road performance analysis of R134a/ R600a/ R290 refrigerant mixture in an automobile air-conditioning system with mineral oil as lubricant. However, to avoid PAG oil and to use the conventional mineral oil as lubricant, R134a is mixed with the commercially available hydrocarbon blend, (45.2% R290 and 56.8% R600a) in the proportion of 91% and 9%, respectively by mass. The quantity of hydrocarbons used is well below the lower flammable limit. This new mixture R134a/R600a/R290 is tested in the air-conditioning system of a passenger car 'on road' in the true running conditions and compared with the results that has been obtained with R12.During pull down using M09 mixture, the rise in discharge pressure is 10% and the reduction in discharge temperature is 5%. The discharge temperature is less by 10% for M09. During wall test, the discharge pressure is 7% more and the discharge temperature is 12% less in the case of M09. During the speed and ambient tests the discharge pressure is 11–13% higher than R12. The discharge temperature of M09 is 3–5% less than R12. The reduction in discharge temperature can increase the life of the compressor. The increase in discharge pressure has increased the compressor work. The refrigeration effect is 25–33% more and the work of compression is 43% more for M09. The increased work of compression reduces the COP by 5–15%.Considering the service issues involved in using the PAG oil as lubricant, this new refrigerant blend M09 is a better drop in substitute for R12. It can be directly used in the R12 systems with mineral oil as lubricant and hence the PAG oil can be dispensed with, without much loss in system performance.

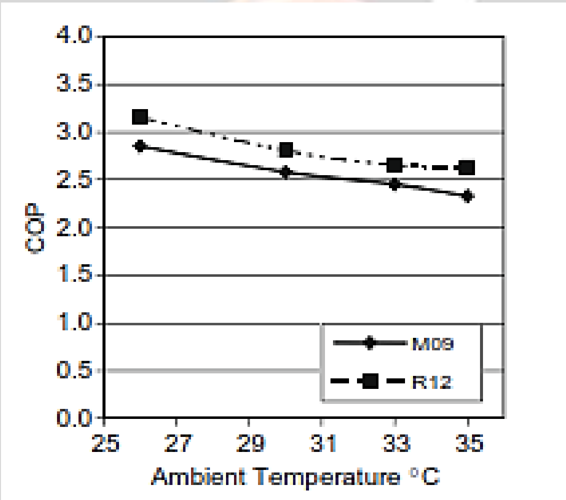

Fig.3.Effect of Ambient temperature on COP for different refrigerant [8]

3. CONCLUSIONS

Performance of VCR system can be improved by using proper refrigerant. The refrigeration systems which are widely used today are based on the conventional vapour compression refrigeration cycle. According to Montreal and Kyoto protocols R12 is already phase out.R134a is the most commonly used refrigerant in the domestic refrigeration due to its excellent thermodynamic properties. But because of its high global warming potential, it will phase out in the recent years. So it is time to introduce new refrigerant which have low global warming potential for the domestic refrigerators.

New refrigerant blend should have Reliability of refrigerant compressors working, low Flammability and safety issues, Environment-friendly, Economic optimization.

Low GWP refrigerant like R290, R600a, R430A, R436A and some newly developed refrigerant R1234yf and R1324ze have been studied as promising drop-in replacement for the high global worming potential refrigerant R134a. R600a and its blend are better option due to their low GWP. HFC134a and HC blend containing 55.2% HC600a and 44.8% HC290 by weight have been reported to be substitutes for R134a for domestic refrigerator. R134a is mixed with the hydrocarbon blend, 45.2% R290 and 56.8% R600a in the proportion of 91% and 9%, respectively by mass have been reported to be substitutes for R134a for automobile air-conditioning system.

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