Literature Survey on Using Blending of Refrigerants

Dr. Shrikant Pandey

Head of Department of Mechanical Engineering SVVV, Indore, M.P.

Abstract-

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. Researchers observed the performance of different environmental friendly refrigerants and their mixtures in different proportions. They 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. From the literature there seems to be need of new efficient, minimum global warming potential (GWP), minimum ozone depletion potential (ODP) and environmental friendly refrigerants.

Index Terms— Vapour Compression Refrigeration System, Refrigerant, COP, ODP, GW

I. INTRODUCTION

With the phasing out of CFC12 and HFC134a, existing refrigeration and air-conditioning appliances will have to be replaced with new appliances or retrofitted with alternative refrigerants. Current research focuses on the development of new refrigerants to retrofit the existing CFC12 and HFC134a systems. Various alternative refrigerants are available to retrofit the conventional systems, but each one has its own merits and demerits. Previous researchers have studied the performance of various alternative refrigerants and their mixtures. In this chapter a comprehensive survey of the previous study on the performance of alternative refrigerants and their mixtures in refrigeration and air conditioning system is presented. The need for and the scope of the present research work have been outlined at the end of the chapter.

ALTERNATIVE REFRIGERANTS AND THEIR PERFORMANCE

Since this study has been focused on retrofitting of existing CFC12 and HFC134a systems with alternative refrigerants, a detailed literature survey related to the performance of HFCs, HCs and their mixtures in refrigeration, heat pump and air conditioning systems has been made.

Bodio et al (1993) have investigated the working parameters of domestic refrigerator filled with propane-butane (methane 0.1%, ethane 4.5%, propane 34%, butane 61.3% and hydrocarbons C_5 0.1%) mixture. It has been reported that the energy consumption was comparable with R12.

Kim et al (1994) conducted a test on heat pump with two azeotropic refrigerant mixtures of R134a/R290 and R134a and R600a. Their experiments indicated that the COP of R134a/R290 was lower than that of R22 and R290. However, R134a and R600a showed higher COP than that of R12 and R134a. The discharge temperature of R134a/R290 was found to be lower than that of R22 and slightly higher than that of R290. For R134a and R600a mixture, the discharge temperature was lower than that of R12.

Sami and Tulej (1994) have evaluated the performance of a new blend of HFCs and HCFCs as a substitute for CFC12, CFC502 and HCFC22. It has been reported that NARM 12 (mixture of HFC123/HFC152a/HCFC22) significantly reduces domestic refrigerator energy consumption.

Billy et al (1995) have conducted an experimental analysis to study the performance of R290/R600 (70/30) blends as drop-in substitute in a domestic refrigerator/freezer. It has been reported that energy savings up to 6% were achieved with 70 g of charge and an additional capillary tube length of 5 ft.

Richardson and Butterworth (1995) have investigated the performance of propane and two propane/isobutane mixture as alternative to R12 refrigerant in an unmodified hermetic vapour compression system. It has been reported that the hydrocarbon mixture with 56% propane and 44% isobutane has a COP greater than that of R12 throughout the range of temperatures investigated. The 43/57% hydrocarbon mixture only achieves a better COP at temperatures above about -10°C. It has also been reported that the COP increases with the proportion of propane is increased.

Sami and Tulej (1995) have investigated the performance of various ternary blends as substitutes to CFC12l in a residential refrigerator. It has been reported that the NARM 12 (mixture of HFC23/HCFC22/HFC152a) consumed 35% less energy than CFC12.

Dongsoo Jung et al (1996) have investigated the performance of R290/R600a mixture in domestic refrigerators as alternative to R12. It has been reported that the mixture at 0.6 mass fraction of R290 showed a 3% to 4% increase in energy efficiency and a faster cooling rate as compared to R12.

Camporese et al (1997) have evaluated the performance of HC290/HFC134a and HCFC22/HFC134a mixtures as substitutes for CFC12. The experimental results revealed that this mixture gives comparable refrigerating capacity and performance with that of CFC12. It has also been reported that the miscibility of mineral lubricants is strongly increased by the addition of a small percentage of hydrocarbon.

Hammed and Alsaad (1999) have investigated the performance of domestic refrigerator with four ratios of propane, butane and isobutane. The HC mixture with 50% propane, 38.3% butane and 11.7% isobutane showed the best performance. This mixture at the evaporator temperature of -16˚C and condenser temperature of 27˚C gave a COP of 3.7 as compared to COP = 3.6 for R12 at the same temperature.

Chang et al (2000) have investigated experimentally the performance of single hydrocarbon refrigerants and binary mixtures of propane/isobutane and propane/butane in a heat pump system with two cylinder open reciprocating type compressors. It has been reported that when zeotropic refrigerant mixtures of R290/R600a and R290/R600 are used, the cooling and heating capacity increases with respect to mass fraction of R290. It has also been reported that the COP of hydrocarbon mixtures for the cooling condition is higher than that of R22 for a wide range of the mixture compositions.

Havelsky (2000) has investigated the performance of R12 alternative working fluids. It has been reported that the use of R134a, R401A and R409A refrigerants enables the increase of COP co-efficient and significantly reduces the value of TEWI.

Lee and Su (2002) have experimentally studied the performance of R600a refrigerant in a domestic refrigeration system. It has been reported that the COPs are between 1.2 and 4.5 in cold storage application and between 0.8 and 3.5 in the freezing application, which are comparable with those of the system with R12 and R22.

Tashtoush et al (2002) have experimentally studied the performance of butane/propane/R134a mixture to replace R12 in domestic refrigerators. It has been reported that the 25g butane/25 g propane and 30 g R134a gives performance characteristics closer to R12. The COP of this mixture was 5.4% and 0.8% less than that of R12 at 100W and 350W evaporator duty respectively.

Bilal and Said (2003) have conducted an experimental investigation to study the performance of LPG with the composition of about 30% propane,
55% n-butane and 15% iso-butane as an alternative to R12 in domestic refrigerators. It has been reported that the cooling capacity and specific compressor work are higher than that of R12 and the COP values are comparable with that of R12 for a mass charge of 80g.

Chao and Chin (2003) have studied the performance of propane in a compression refrigeration system with two evaporators. It has been reported that the cooling capacity of high temperature evaporator decreases and that of the low temperature evaporator increases with fixed lengths of capillary tubes and both the mass flow rate of refrigerant and suction pressure of the system increase with condensing pressure. It has also been reported that for a fixed condensing pressure and length of the capillary tube for high temperature evaporator is increased while that for low temperature evaporator is fixed, the cooling capacity of the high temperature evaporator increases while that of the low temperature evaporator decreases.

Halimic et al (2003) have conducted performance test with R401A, R290 and R134a as alternative to R12. It has been reported that the cooling capacity of R290 was the largest of the refrigerants tested and COP was found to be similar to that of R12. The test results indicated that the performance of R134a is very similar to that of R12. When viewed in terms of green house impact however R290 showed the best performance.

yields the highest COP of all the tested hydrocarbon mixtures and HFC134a. It has also been reported that the refrigeration capacity, compressor power consumption and COP were 41%, 21% and 17% higher than that of HFC134a.

MISCIBILITY ASPECTS OF R-s/HCs WITH MINERAL OIL

The addition of a small quantity of hydrocarbon, which is well soluble in mineral oil, could reduce the viscosity of the lubricant accumulated in the evaporator sufficiently to guarantee the lubricant’s return to the compressor, In addition, this concept could also reduce the flammability issues in HC refrigerants.

Kim et al (1994) have reported that in refrigeration system the lack of mineral oil solubility with chlorine free refrigerants was a matter of concern in the context of ODS phase out.

Janssen and Engels (1995) have reported that the addition of 5% isobutane could take care of the return of mineral oil from evaporator into compressor. Experiments conducted in domestic appliances with 8% isobutane as an additive with R134a have shown an improvement in the performance of the appliance.

Mathur (1996) has presented the performance of vapour compression refrigeration system with hydrocarbons such as propane, isobutane and 50/50 mixture of propane/isobutane. It has been reported that mineral oils are compatible with hydrocarbons.

Camporese et al (1997) have reported that the addition of R290 with R134a resulted in an increase in the refrigerating capacity, which was roughly proportional to the mass fraction of R290. At the lower evaporating temperature, the COP was unaffected by the mass fraction of R290 but at the higher evaporating temperature, the COP was slightly decreasing with the increase in mass fraction of HC. It was also observed that the miscibility of the mineral oil has increased considerably by even a small mass fraction of hydrocarbon.

Herbe and Lundqvist (1997) have investigated the level of acid, moisture and residual mineral oil in a retrofitted refrigeration system and heat pumps. It has been observed that if the percentage of the moisture content and residual mineral oil were kept below the stipulated levels, the system could run without any problem. It has also been indicated that copper plating was not significant in those places where proper evacuation had been carried out before charging.

Alok and Agarwal (1998) have studied the performance of R134a/R600a mixture as a possible drop in substitute for R12 in a horizontal bottle cooler. It has been reported that the COP of the system was 8% less than that of R12.

Colbourne and Ritter (1998) have reported that the replacement of conventional refrigerants by hydrocarbon refrigerants could lead to a small increase in risk but that increase was negligible as compared to the background levels.

Masato et al (1999) have reported that even 5% residual mineral oil concentration could make the POE oil to be immiscible. It has also been recommended that the oil tank and pipelines in refrigeration systems should be adequately flushed during retrofitting.

Tashtoush et al (2002) have experimentally studied the performance of a 320 litre R12 domestic refrigerator charged with mixtures of HC and HFC refrigerants. The results showed that the R600/R290/R134a mixture could provide excellent performance parameters such as coefficient of performance, compressor power, volumetric efficiency, condenser duty, compressor discharge pressure and temperature as compared to R12.

Joseph et al (2003) have studied the performance of R134a/HC blend refrigerant mixture as a possible drop in substitute for R12 in a domestic refrigerator. It has been reported that the addition of 9% of HC blend (R290/R600a) with R134a could solve the miscibility problem and also improve the performance of the system.

Based on the above observations it has been recognized that the addition of LPG with R134a could solve the oil miscibility issues of LPG/R134a mixture with mineral oil and is expected to improve the system performance. The need for research to identify a suitable HC blend and LPG/R134a blend as a suitable substitute for CFC12 and HFC 134a in the CFC12 and HFC134a system is realized. The lubrication of compressor bearing is a critical issue in refrigeration system design. But with the magnetic bearings this issue is avoided. Magnetic bearing is a bearing which supports load using magnetic levitation. Magnetic bearing compressors offer economic, energy and environmental benefits, including increased energy efficiency, the elimination of oil and it is considerably less weight, less noise and vibration.

BEHAVIOUR OF ZEORTROPIC REFRIGERANT MIXTURE

Since this study has been focused on zeotropic mixtures, knowledge of their behaviour is essential to study their performance. A detailed literature survey has been done to highlight the possible issues of zeotropic mixtures in refrigeration systems.

David and Donald (1990) have reported that refrigerant mixtures provide solution to the problem of alternatives to CFCs. It has also been reported that the azeotropes, near-azeotropes and zeotropes are the three categories of mixture which can be used as working fluids. The mixing of two or more refrigerants provides an opportunity to adjust or tune those properties that are most desirable.

Akio Miyara et al (1992) have experimentally studied the performance of Non-Azeotropic Refrigerant Mixtures (NARMs) of R22/R114 in a vapour compression heat pump cycle. It has been reported that the COP of NARMs is higher than that of pure refrigerants.

Venkataratnam et al (1996) have reported that the pinch point would occur only in the condensation or evaporation region of the heat exchangers for zeotropic mixtures. It has also been found that the perfect glide matching might not be possible when two phase enthalpy varies non- linearly with temperature, and if the variation was significant, temperature pinches occur somewhere within the ends of the condenser and evaporator depending on the nature of the enthalpy curve. Equations to find the pinch conditions of 300 zeotropes have also been reported.

Frank and Dennis (1997) have reported that the composition shift was very small by 1% or less when liquid blend was filled from a storage tank. It has been found that the fractionation effect was increased exponentially as the liquid level drops below 10% of the total volume of the tank. The following observations have also been made regarding the fractionation of zeotropic blends.

- Fractionation of a non-azeotropic blend in a system would only occur when there is a potential for significant liquid hold- up or storage.

- Leaks could alter the composition of the refrigerant blend and were most significant when they occur in the vapour side while the systems are off.

- Recharging the system after a leak with a blend of the original composition would bring the blend closer to the original system compositon.

- Charging at nominal room temperatures at any reasonable rate would not produce major composition changes.

Horst and Florian (1997) have reported that the concentration shift in non-azeotropic mixtures was due to the factors such as leakage of refrigerant mixture, thermodynamic behaviour of refrigerant mixtures in two- phase regions, and differential solubility of the components of refrigerant mixtures in lubricant oil. It has been reported that the overall average concentration in the heat exchangers with two-phase regions was different from that of the concentration at charging.

Purkayastha and Bansal (1998) in their experimental study on HC290 and LPG mix as replacements for HCFC22 reported that the hydrocarbon refrigerants performed better than HCFC22 but with small loss of condenser capacity. The mass flow rate and compressor discharge temperatures were found to be significantly lower than HCFC22. Their study revealed that LPG could be an excellent refrigerant in heat pump and refrigeration applications.

Leelananda Rajapaksha (2007) has reported different design and operational aspects of using zeotropic refrigerant mixtures, relative to the use of pure refrigerants, in vapour compression refrigeration systems. It has been reported that the composition shift and temperature glide are the two attributes associated with the phase changing process of zeotropic mixtures and exert significant influences on the heat transfer behaviour. It has also been reported that a temperature glide of about 5°C or larger offer a theoretical potential to improve the performance and efficiency of vapour compression systems.

The studies carried out on the behaviour of zeotropic blends in the above literatures show that the handling of the above blends are very critical. Hence when these refrigerants are used for testing, care must be exercised to avoid concentration shifts. The necessary procedure to prepare and charge the zeotropic refrigerant has also been understood from these literatures, which were highly useful for this study.

SAFETY ASPECTS OF USING HYDROCARBON REFRIGERANTS

Maclaine-cross and Leonardi (1995) have reported the safety of using LPG refrigerants in refrigeration and air-conditioning equipments. It has been reported that LPG mixtures have successfully replaced R12 and R134a in car air-conditioners.

Evelyn Baskin (1998) has conducted experimental test on residential refrigerator/freezers using hydrofluorocarbon and hydrocarbons. It has been reported that the mixtures 60/40% and 70/30% of isobutane/propane were the best overall mixtures. It has also been reported that the risk of flammability due to leakage is reduced due to the hermetic seal of refrigerators/freezers.

William and John Dieckmann (2002) have presented an overview about the risks, benefits and regulations associated with the use of highly flammable A3 refrigerants in air-conditioning and commercial refrigeration systems. It has been reported that the low GWP compared to fluorochemical refrigerants is the primary reason for considering hydrocarbon refrigerants. It has also been reported that explosion or fire is the most critical risk associated with hydrocarbon refrigerants.

Andrew Gigiel (2004) has carried out safety tests in a domestic refrigerator with flammable refrigerant according to the methods specified in the safety standard, IEC/EN 60335-2-24. The following observations were made

- use non-sparking electrics for low-level compressors
- have no sources of ignition in the compartment
- give guidance to users on the need for ventilation and the position of ignition sources other than the refrigerator.

PERFORMANCE STUDIES ON VAPOUR COMPRESSION REFRIGERATION SYSTEM

Jung and Radermacher (1991a) have performed a simulation study of single-evaporator domestic refrigerators charged with pure and mixed refrigerants to find possible alternatives for R12. They considered the realistic cycle with subcooling and superheating in condenser and evaporator respectively. The pressure drops and the liquid –to-suction heat exchange were also accounted for. The condenser was assumed to be forced convection type and of such a size that sub cooled liquid exits. The performance of various fluids was compared on the basis of constant net refrigeration effect, regardless of the working fluid. The air stream temperatures entering and leaving the evaporator with fixed mass flow rate were specified as input parameters. The compressor power and COP varies with the working fluids. The compressor was assumed to be a positive displacement machine and the non-ideal compression process was assigned an isentropic compressor efficiency of 55%. Both successive substitution and Newton-Raphson methods were used to determine the unknown parameters resulting from the simulation of steady-state thermal systems. The thermodynamic properties required in the cycle calculation were calculated by CSD equation of state.

The model was applied to 15 pure and 21 mixed refrigerants. Some of the pure fluids are 134a, R32, R152a, R123, R124, R143a, R125 and the mixtures considered were made of some of these pure fluids. Their findings show that no single pure refrigerant studied can be a drop-in replacement for R12 unless some modifications are made in the compressor. Out of 21 mixtures studied at various compositions, no significant increase in COP was observed. Some mixtures yield a small COP improvement in the range of 3-5% compared to R12.

Jung and Radermacher (1991b) have performed a computer simulation of two-evaporator refrigerators charged with pure and mixed refrigerants to determine possible substitutes for R12 with improved energy efficiency. The simulation model was the same as discussed previously by Jung and Radermacher (1991), with an additional evaporator and a liquid- suction heat exchanger. The values for the product of overall heat transfer coefficient and heat exchanger area (UA) for the condenser and the evaporator were specified as inputs along with the mass flow rate and the inlet and outlet temperatures of the air flowing over the evaporators. The overall heat transfer coefficients for the condenser and the liquid-suction heat exchanger were assumed to be equal to that in the evaporator. The Newton-Raphson and successive substitution methods were used to find the unknown parameters. The performance comparison of various fluids was done on the basis of constant cooling duty.

Devotta et al (1993) have theoretically analyzed the suitability of HFCs, fluorinated ethers (HFEs) and amines as alternatives to R12 using the standard refrigeration performance parameters including pressure ratio, specific compressor displacement, theoretical Rankine COP and shaft power per ton of refrigeration. It has been reported that from the energy point of view HFC152a is the best. HFC134 is more efficient than that of HFC134a. The COP of HFC134a is slightly less than that of CFC12.

Charters (1996) has simulated the vapour compression cycle using CFC12, HCFC22 and propane as working fluids for a range of evaporating temperatures at constant condensing temperature. The practical consideration like safety, compatibility has also been discussed. The theoretical predictions have shown that the heating COPs for propane are almost the same as that for low evaporating temperatures (-20℃ to -10℃) while SCD is less for propane than that of CFC12. The flammability problem was reduced since the charge of propane in the system was small.

Jung et al (1996) have carried out both thermodynamic cycle analysis and experimental investigation of a single evaporator domestic refrigerator with propane/isobutane (R290/R600a) mixture as an alternative to R12. The thermodynamic simulations were carried out at constant cooling load for all fluids by varying the compressor size to match the cooling load. They used the same cycle simulation method (SERCLE) as that of Jung and Radermacher (1991). The cycle analysis was performed for R12 and mixtures R290/R600a for the mass fraction range of zero to unity R290. The predicted COP of the mixture was 1.7-2.4% higher than that of R12 in the R290 mass fraction range of 0.2-0.6. The volumetric capacity ratio increases linearly as R290 is added and at 0.55 to 0.6 mass fraction of R290, the VCR of the mixture becomes close to that of R12.

COMPRESSOR PERFORMANCE WITH ALTERNATIVE REFRIGERANTS

The compressors available in the existing systems are designed for the conventional refrigerants. Hence their behaviour with alternative refrigerants has to be ascertained to ensure the energy efficiency and also life of the retrofitted systems.

Chen et al (1994) have investigated the feasibility of using hydrocarbon mixtures in residential air conditioning and heat pumps. A mixture of HC290 and HC600 gave the highest COP. It has been considered to represent the best balance between COP and volumetric capacity for hydrocarbons. The disadvantage with HC290/HC600 is its low volumetric capacity.

Riffat et al (1996) have reported that the alternative refrigerants like ammonia, hydrocarbons, carbon dioxide, water and air demand for special changes in the main system components like compressor, evaporator and control devices.

Agarwal (1998) has reported that one of the important advantages of HC600a/HC290 blend is that it was compatible with mineral oil and commonly used materials for manufacturing of refrigeration systems. It has been also reported that it requires minimal or no changes while retrofitting CFC12 refrigeration system.

Devotta et al (1998) have tested the reliability of various parts in a hermetic compressor with alternative refrigerants and reported that the hydrocarbon blend has better compatibility with hermetic compressor components.

Tassou and Qureshi (1998) have investigated the performance of positive-displacement refrigeration compressors for variable speed refrigeration applications. Compressors tested include an open type reciprocating, a semi-hermetic reciprocating and an open type rotary vane. It has been reported that the open type reciprocating compressor to be the most efficient for variable speed operation.

Gursaran (2000) has compared the pressure gradients for hydrocarbons R290, R600a and the mixture pf R290/R600a with those of R12 and R134a. He has reported that the pressure gradients for hydrocarbons are significantly higher than for both R12 and R134a.

Mehmet Yilmaz (2003) has analysed the performance of a vapour compression heat pump using pure and zeotropic refrigerant mixtures with open hermetic type variable speed compressor. It has been reported that the mixture ratio affects the COP and the second law efficiency. The COP and the second law efficiency for the pure refrigerants could be improved by using an appropriate mixture of the refrigerants.

Minsung and Min (2005) have experimentally investigated the effect of four artificial faults on the performance of a variable speed vapour compression system with an open type reciprocating compressor. It has been reported that the system parameters are less sensitive to the faults at a variable speed condition. It has also been reported that for a fault detection and diagnosis system COP degradation due to the fault in a variable speed system is severer than that in a constant speed system.

The performances of the compressors with alternative refrigerants discussed in the above papers show that mixtures would offer better system reliability, fluid stability than CFC12 and HFC134a but natural refrigerants need compressor modifications which may not be viable while retrofitting the existing CFC12 and HFC134a systems with new refrigerants. Screw compressor and Centrifugal chillers are also used in refrigeration and air conditioning applications. Unlike reciprocating compressors, the refrigeration capacity range of screw compressor and centrifugal chillers are high and they are used for large and medium refrigeration and air conditioning applications.

PERFORMANCE OF ALTERNATIVE REFRIGERANTS IN HEAT EXCHANGERS

The evaporation and condensation heat transfer of alternative refrigerants in refrigeration system decides the refrigeration effect and energy efficiency of the systems. A study of the heat transfer characteristics is also important to understand the behaviour of heat exchangers with alternative refrigerants.

McLinden and Radermacher (1987) have used characteristic condensation and evaporation temperatures to compare the different zeotropic mixtures. It has been found that the COP of the system could be increased due to the temperature glide of the zeotropes during phase change.

Kuijpers et al (1988) have reported that the criticality in optimizing the capillary was reduced by a large condenser. It has also been mentioned that the use of a larger condenser leads to a lower condensation pressure and in turn to a higher efficiency.

Jung and Radermacher (1993) have reported that the heat transfer coefficients of zeotropic mixtures reduced with an increase in temperature glide. It has also been reported that the heat transfer coefficient was more sensitive to the properties of liquid than those of vapour.

Chang et al (2000) have investigated experimentally the heat transfer characteristics of pure hydrocarbon refrigerants and binary mixtures of propane/isobutane and propane/butane in heat pump system with open reciprocating type compressor. It has been reported that hydrocarbon refrigerant have a higher thermal conductivity and a lower viscosity in the liquid phase than R22 which is a potential for higher heat transfer coefficient in the evaporator and condenser.

Ho-Saeng et al (2006) have experimentally studied the condensing and evaporating heat transfer characteristics of hydrocarbon refrigerants (R-290, R-600a and R1270) in a vapour compression heat pump with horizontal double pipe heat exchanger. It has been reported that the condensing and evaporating heat transfer coefficients in hydrocarbon refrigerants were higher than that of R22.

ARTIFICIAL NEURAL NETWORK MODEL

The use of Artificial Neural Networks (ANNs) for modeling and prediction purposes is becoming increasingly popular.

Kawashima et al (1996) have predicted the next day cooling load for a chiller and ice-storage system using neural networks. The ANN consisted of 12 inputs, mostly temperature and solar insulation data and predicted the thermal load. An ANN model was chosen because of its abilities in modeling non-linear systems and easy adaptation to practical systems. Data collected over three months were used for the training of the network. The accuracy of the prediction was within 3% when accurate weather data were used.

Bechtler et al (2001) have presented a new Artificial Neural

Network approach of modeling dynamic processes of vapour compression liquid chillers. The input parameters of the network are chilled water outlet temperature, cooling water inlet temperature and evaporator capacity. Neural network then predicts all relevant performance parameters such as chilled water inlet temperature, compressor electrical input and coefficient of performance. It has been reported that the results predicted by the generalized radial basis function (GRBF) network was satisfactory and has shown a higher accuracy if the modeled process had a more smooth behavior.

Swider et al (2001) have presented a Neural Network Model of vapour compression liquid chillers. A generalized radial basis function network was applied to two different chillers. The input parameter of the network includes cooling capacity, chilled water outlet temperature and cooling water inlet temperature. It has been reported that the model predicted all the relevant performance parameters such as chilled water inlet temperature, cooling water outlet temperature, compressor work input and COP. It has also been reported that the neural network predicted the compressor work input and the COP to within ±5% for both the chillers.

Erol Arcaklioglu (2004) has studied the performance CFCs with their substitutes using Artificial Neural Network. Mixings ratios of refrigerants and evaporator temperature were used as input parameters, COP and TI values were used as output parameters. It has been reported that ANNs can be used for prediction of coefficient of performance and Total irreversibility as an accurate method in the systems.

Navarro Esbri et al (2007) have developed a neural network model of a vapour compression refrigeration system with a variable speed compressor. The model input parameters are inlet chilled water temperature, inlet condensing temperature, refrigerant evaporator outlet temperature and compressor rotation speed. The output parameters are cooling capacity, electrical power consumption of the compressor and the chilled water outlet temperature. It has been reported that the results obtained from these models accurately predicts the performance of the system and are in good agreement with measured data.

BEHAVIOUR OF REFRIGERANTS WITH MAGNETIC FIELD

Samuel and Shawn (2003) have conducted performance test with R-410A, R-507, R-407C and R-404 A under various conditions of magnetic field using an air-source heat pump set-up. It has been reported that as the magnetic field force increases, compressor head pressure and discharge temperature slightly increases as well as less liquid refrigerant is boiling in the compressor shell. It has also been reported that the higher gauss level magnets results in decreasing the power consumption and therefore enhance the COP.

Samuel and Kita (2005) have studied the behaviour of new alternative refrigerant mixtures such as R-410A, R-507, R-407C and R-404 A under various conditions of the magnetic field. It has been reported that the effect of the magnetic field on the mixture behaviour varies from one mixture to another depending upon the mixture composition and its boiling point and consequently on the thermo physical properties. It has also been reported that the thermal capacities of the condenser and the evaporator depending upon the refrigerant mixture's thermo physical properties.

CONCLUSION

The literature survey presented gives an idea about the various alternative refrigerants available to retrofit the conventional systems with its own merits and demerits. In the subsequent sections the detailed literature survey given provides the ways to find a new environmental friendly alternative refrigerant mixture to be used in a vapour compression refrigeration system to improve the performance.

References

[1]B.O Bolaji and Z. Huan. Energy Performance of Eco-friendly RE170 and R510a Refrigerants as Alternatives to R134a in Vapour Compression, Refrigeration System.

[2]Somchai Wongwises, Nares Chimers, Experimental Study of Hydrocarbon Mixture to replace HFC-134a in a domestic refrigerator. Energy conservation and management 46 (2005) 85-100.

[3]Amjad khan, Dr. Kuldeep Ojha and Prakash Gowali, Analysis of Modern Eco-Friendly Refrigerant, International Journal on Emerging Technologies 4(1):177-181(2013).

[4]Gaurav,Dr. rajkumar, Alternative to R134a (CF3CH2F) Refrigerant – A Review, YMCA University of Science & Technology, Faridabad, Haryana, Oct 19-20, 2012.

[5]Mohd. Aasim Nazeer Ahamad, Chidanand Mangrulkar, Ehsanullah Khan, Syed Mohiuddin, Experimental analysis of refrigerator by replacing conventional HFC refrigerants with hydrocarbons, IOSR-JMCE, e-ISSN: 2278-1684, p-ISSN: 2320-334X PP 01-05. ISSN: 2348 9510
International Journal Of Core Engineering & Management (IJCEM) Volume 2, Issue 7, October 2015 34
[6]Jetendra kumar verma, Ankit satsangi, vishal chaturani, A Review of Alternative to R134a (CH3CH2F) Refrigerant, International Journal of Emerging Technology and Advanced Engineering, Volume 3, Issue 1, January 2013.

[7]L. Maclaine-cross, E. Leonardi, Performance and safety of LPG refrigeration's, School of mechanical and manufacturing engineering the university of new south wells, Sydney NSW, Australia 2025.

[8]Mohd.Aasim Nazeer Ahmad, Chaidnand Mangrulkar, Ehsanullah Khan, Syed Mohiuddin, Experimental analysis of refrigerator by replacing conventional HFC refrigerants with hydrocarbons, IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE) e-ISSN: 2278-1684, P-ISSN: 2320-334X PP 01-05.

[9]N. Austin, Dr. P. Senthil kumar, N. kanthavelkumaran, thermodynamic optimization of household refrigerator using propane–butane as mixed refrigerant, international journal of engineering research and applications (IJERA) issn: 2248-9622, vol. 2, issue 6, NovemberDecember-2012, PP.268-271.

[10]The Air Conditioning and Refrigeration Industry Board, Guidelines for the use of hydrocarbon refrigerants in static refrigeration and air conditioning system.

[11]Vishwadipsinh J. Ghariya, Swastik R. Gajjar, Thermodynamically Evolution of LPG Refrigerator for Restaurant, IJSRD - International Journal for Scientific Research & Development, Vol. 2, Issue 03, 2014 ISSN (online) 2321-0613.

[12]Vishwadipsinh J. Ghariya, Dipak C. Gosai, Swastik R.Gajjar, Thermodynamically Evolution of LPG Refrigerator : A Literature Review, International Journal of Engineering Research & Technology (IJERT)Vol. 2 Issue 12, December-2013,ISSN: 2278-0181. ISSN: 2348 9510 International Journal Of Core Engineering & Management (IJCEM) Volume 2, Issue 7, October 2015 35

[13]P. Thangavel, Dr. P. Somasundaram, T. Sivakumar, C. Selva Kumar, G. Vetriselvan, Simulation Analysis of Compression Refrigeration Cycle with Different Refrigerants, International Journal of Engineering and Innovative Technology (IJEIT) Volume 2, Issue 10, April 2013.

[14]Moises A. MARCELINO NETO, Jader R.BARBOSA Jr, Absorption of Isobutane (R-600a) in Lubricant Oil, International Compressor Engineering Conference, Federal University of Santa Catarina 2010.

[15]The use of hydrocarbons propane and isobutane in Refrigeration systems, 18th International Congress of Mechanical Engineering Copyright © 2005 by ABCM November 6-11, 2005, Ouro Preto, MG.

[16]Guidelines for the safe use of hydrocarbon refrigerants, A handbook for engineers, technicians, trainers and policy-makers - For a climate-friendly cooling, Eschborn, September 2010.

[17]Zainal zakaria & zulaikha shahrum, the possibility of using liquefied petroleum gas in domestic refrigeration systems, IJRRAS 9 (3), December 2011.

[18]Anil S.Katarkar & Lenin Dhale, Coefficient of Performance increment in Domestic Refrigerator: A Literature Review, International Journal of Engineering Research & Technology (IJERT) ISSN: 2278-0181, Vol. 3 Issue 4, April – 2014