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Possibility of Using Refrigerant Blends In the Existing Refrigerator & AC Systems: A Review

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Abstract: *The heat transfer performance is one of the prominent research areas in thermal engineering. To transfer heat from low temperature reservoir to high temperature reservoir, numbers of refrigerants were used by different refrigeration systems. Their environmental effects like toxicity, Flammability and high pressure made them more hazardous according to safety and environmental issues. For society's standard of living the availability and application of refrigeration technology is important. Preserving food products and medical appliances' are key contributors to quality of life. The refrigeration sector is divided into mainly 5 categories like Domestic refrigeration, Commercial refrigeration, food processing and cold storage, industrial refrigeration, Transport refrigeration. Conversion of historic refrigerants to ozone safe alternatives is initiated in response to Montreal Protocol. The most commonly used late 1800's and early 1900's refrigerants were natural refrigerants such as ammonia, carbon dioxide, sulphurdioxide and methyl chloride which were toxic and hazardous. In 1920's alternative refrigerants became available with the invention of CFC's and HCFC's which were stable , nontoxic, non-flammable having good thermodynamic properties. Later results from many researchers showed that the reason for the depletion of ozone layer is the presence of chlorine in the stratosphere. In search of finding alternative to CFC's and HCFC's researchers showed that Hydrocarbons (HC's) or Refrigerant blends are good alternatives to the existing ones. So in the process of searching for alternative refrigerants, instead of single refrigerant, refrigerant blends were actually suggested by the researchers. Refrigerant blend can be prepared by mixing two or more refrigerants to form a new working fluid with the desired characteristics. So many researchers are working on them to find out new refrigerants with low global warming potential (GWP) and ozone depletion potential (ODP).The objective of this paper is to investigate a new ozone friendly alternative refrigerant blend in refrigeration and air conditioning systems.*
Keywords: *Alternatives refrigerants, Domestic refrigerator, New Refrigerants, ozone friendly refrigerant, Refrigerant Blends*

I. Introduction

A refrigerator or an air conditioner is nothing but a heat pump whose job is to reject heat to a higher temperature sink by removing heat from a lower temperature source. Natural ice was harvested, distributed and used in both commercial and domestic applications. In 1834 the first mechanically produced cooling system was developed in England which later known as vapor compression. The vapor refrigeration cycle is the process that cools an enclosed space to a temperature lower than the surroundings. Since the invention of vapor compression refrigeration system, the application of refrigeration has entered many fields which include preservation of food, medicine, air-conditioning for comfort and industrial applications. Refrigerant is a working fluid used to transfer heat from low temperature reservoir to high temperature reservoir.

There are different refrigerants like CFC, HCFC, CO2, NH3 etc. CO2 requires special compressors and NH3 is toxic and flammable. Chlorofluorocarbons [CFC's] and hydro chlorofluorocarbons [HCFC's] have less toxicity, material compatibility and non flammability that have led to their widespread use by both consumers and industries around the world as refrigerants in refrigeration and air conditioning systems. This presence of chlorine atoms removes zone in the atmosphere and later these chlorine atoms continues to convert ozone to oxygen. Hydro fluorocarbons [HFC's] and Hydrocarbons [HC's] are an alternate for CFC's and HCFC's in which there are no chlorine atoms and not participate in destroying ozone layer. R134a and R152a belongs to the family of HFC's and R290, R600, R600a belongs to the family of HC's. Scientists and Researchers are searching for a new ozone friendly refrigerant for the domestic refrigerator and freezer. So it is necessary to prepare an environment friendly refrigerant to meet those needs without compromising future international commitments to protect the environment by reducing the green house gas emissions and protecting the ozone layer.

In the process of searching for new alternative, instead of using single refrigerant we can achieve better performance characteristics by mixing two or more refrigerants to get a new working fluid with the desired characteristics which are known as refrigerant blends. Refrigerant blends are mixtures of refrigerants containing 2, 3 or 4 components that have been formulated to provide a match to certain properties of the refrigerants originally used. We can observe the various refrigerants used by various generations and the type of importance given to them.

For example:

- R-410A consists of two refrigerants: R-32 and -125;
- R-404A consists of three refrigerants: R-125, -143a, and -134a;
- R-427A consists of four refrigerants: R-32, -125, -143a, and -134a; and
- R-438A consists of five refrigerants: R-32, -125, -134a, -600, and -601a.

The blends to replace R-22 are currently widely used around the world are HFC based such as R-407C and R-410A. The blends to replace R-12 and R-134a are HCFC based such as R-406A and R-415B. In the below table

We can observe the various refrigerants used by various generations and the type of importance given to them.

Importance given	Generation	Type of Refrigerants
What ever Worked	1st Generation	CO2, NH3, H2O, CCL4,etc.
To Safety and Durability	2nd Generation	CFC, HCFC's, NH3,H2O, etc.
To ODP (Ozone depletion Potential)	3rd Generation	HCFC's, HFC's, CO2,NH3,etc.
To GWP(Global Warming Potential)	4th Generation	HC, Refrigerant Blends

Single-component refrigerants, such as R-22, R -32, R-123, R-125, R-134a, R-143a, R-290 (propane), R-600 (isobutane), and R-601a (isopentane), to name a few, have only one molecule in their structures so they evaporate and condense at one constant temperature for a given pressure. This means their saturated liquid and saturated vapor temperatures are the same for one given pressure. In both the evaporator and the condenser, both liquid and vapor exist in equilibrium. As a result, the temperature glide of a single-component refrigerant is zero. Zeotropic refrigerant blends behave like a mixture of the individual components. Their liquid and vapor composition is different at most given temperatures and pressures. They exhibit temperature glide and are represented by the 400-series blends. Examples of these are R-401A, -407C, -409A, and -438A, to name a few. Azeotropic refrigerant blends behave like single-component refrigerants. The composition of the vapor phase and liquid phase is the same for Azeotropic refrigerant mixtures at their Azeotropic temperatures and pressures. When these blends are mixed in precise proportions, they act like a compound that has a boiling temperature independent of the boiling temperature of the individual liquids. They do not exhibit any noticeable temperature glide. These blends are represented by the 500-series blends. Some examples are R-500, -502, and -507. Near-Azeotropic refrigerant blends act similarly to an azeotropic blend; however, these blends exhibit a small but noticeable amount of temperature glide when they phase change. These blends have predictable blend properties, but the difference between these properties and what is observed for single-component refrigerants is not very significant. Examples of these blends are R-410A, -404A, and many other refrigerant blends.

Let’s look at an example refrigerant blend — R-438A — and see what each component contains,

R-438A is an R-22 retrofit refrigerant blend consisting of R-32, R-125, R-134a, R-600, and R-601a. The weight percentages of the five components are 8.5, 45, 44.2, 1.7, and 0.6 percent, respectively. R-438A typically yields 5-10 percent lower capacities and similar energy efficiency ratios (EERs) when compared to R-22. R-438A has similar pressure/enthalpy characteristics compared to R-22 in low- and medium-temperature refrigeration systems and air conditioning applications..

There are many interaction parameters chemical companies face when blending refrigerants to meet certain properties of the refrigerants they’re trying to replace. Much of this information, which is a science unto itself, is proprietary. Many times, depending if the blend is azeotropic or zeotropic when these blends are mixed in precise proportions, they act like compounds that have a boiling temperature independent of the boiling temperature of the individual liquids. Other qualities and properties of blends also may follow this phenomenon. Other properties (to mention a few) that affect performances of refrigerant blends are:Vapor densities, Liquid densities, Operating pressures, Compression ratios, Volumetric efficiencies, Coefficient of performances, Net refrigeration effects, Latent heat values, Heats of compression, Compressor discharge temperatures and Overall efficiencies. It’s very important to follow all safety procedures and retrofit guidelines when retrofitting a system with a refrigerant blend. By all means, one should never try to blend any refrigerants without any experts supervision because dangerous conditions and personal injury may occur.

II. Literature Review

Francisco Ramirez et al..[2015] experimentally measured Two phase flow pressure drop in condensation and evaporation processes using R134a and R32 as working fluids in two multiport aluminum mini channel tubes with a hydraulic diameter’s of 0.715 mm and 1.16mm. Matheus P. Portoa et al [2015] provided a comprehensive experimental study on the determination of heat transfer coefficients for R-22, R-134a, and the predefined refrigerant blends R-404A and R-407C. Srinivas Garimella et al[2015] investigated

Cooling of refrigerant blends R404A and R410A at critical and supercritical pressures in horizontal tubes with $0.76 < D < 9.4$ mm. Local heat transfer coefficients and pressure drops are measured at Pr = 1.0, 1.1 and 1.2, mass fluxes of $200 < G < 800$ kg m−2 s−1, and temperatures ranging from 30–110 °C. The sharp variations in the fluid properties in the vicinity of the critical point are found to have a substantial effect on heat transfer coefficients. Due to these abrupt property variations, the heat transfer coefficients show sharp peaks near the critical temperature. In his paper Qiqi Tian et al [2015] investigated the refrigerant mixture R32/R290 (68%/32% by weight) as the drop-in replacement for R410A in household air conditioners. The GWP of it is only 22% of that of R410A. Theoretical and experimental investigations are conducted on the performance of the air conditioners working with both R32/R290 and R410A. Experimental results show that the refrigerant charge amount of R32/R290 is reduced by 30.0%–35.0%; the cooling and heating capacities are increased by 14.0%–23.7%. For further reducing charge amount and flammability, the micro-channel heat exchanger (condenser) is employed to replace the finned tube one. Compared with the R32/R290 system using finned tube heat exchanger, the R32/R290 charge amount and the power consumption are reduced by 34.1% and 0.4%, respectively; the cooling capacity and the COP are increased by 6.4% and 6.8%, respectively. M.A. Akhavan-Behabadi [2015] carried out an experimental study on heat transfer characteristics of a nano-refrigerant flow during condensation inside a horizontal smooth tube. Experiments conducted for three different working fluid types including: (i) pure refrigerant (R600a); (ii) refrigerant/lubricant (R600a/oil); and (iii) nano-refrigerant: refrigerant/lubricant/nanoparticles (R600a/oil/CuO).

J.S. Fleming [2015] presented a method which ranks single fluid refrigerants in order of thermodynamic effectiveness. Blends can be included in the ranking if their viscosity is adjusted to account for blend constituent interactions. This is achieved by the empirical use of molecular acentricity and dipole moment values for the constituent fluids. Jeremy smith et al..[2014] experimentally measured the two phase flow boiling heat transfer and pressure drop of two new LGWP developmental refrigerants alternative to R-410a.Only Data of local two phase flow HTC and pressure drop are presented for refrigerants R-410a,R-32, R1234yf and the two new refrigerants DR-5 and DR-5A. Mark O. McLinden[2014] explored the possibilities for refrigerants having low global warming potential (GWP). A set of about 1200 candidate fluids is identified from more than 56 000 small molecules examined by applying screening criteria to estimates for GWP, flammability, stability, toxicity, and critical temperature. Khalid A. Joudia et al. [2014] experimentally investigated Steady state performance of residential air conditioning systems using R22 and alternatives R290, R407C, R410A, at high ambient temperatures. System performance parameters such as optimum refrigerant charge, coefficient of performance, cooling capacity, power consumption, pressure ratio, power per ton of refrigeration and TEWI environmental factor have been determined. All refrigerants were tested in the cooling mode operation under high ambient air temperatures, up to 55 °C, to determine their suitability. Two split type air conditioner of 1 and 2 TR capacities were used. A psychrometric test facility was constructed consisting of a conditioned cool compartment and an environmental duct serving the condenser. Air inside the conditioned compartment was maintained at 25 °C dry bulb and 19 °C wet bulb for all tests. In the environmental duct, the ambient air temperature was varied from 35 °C to 55 °C in 5 °C increments. The study showed that R290 is the better candidate to replace R22 under high ambient air temperatures. It has lower TEWI values and a better coefficient of performance than the other refrigerants tested. It is suitable as a drop-in refrigerant. R407C has the closest performance to R22, followed by R410A. In Hak Soo Kim et al. [2014 discussed the experimental results of oil retention amount and pressure drop in the gas line of refrigerant. R410A and polyvinylether oil were used as refrigerant and lubricant, respectively. The experiment was conducted under various pipe inner diameters of 14.1, 17.3 and 26.0 mm, and refrigerant mass flux and oil circulation ratio (OCR) were varied from 40 to 250 kg m−2 s−1 and 0.5–4.0%, respectively. The oil retention amount tends to increase as refrigerant mass flux decreases and OCR increases. The oil retention amount in vertical pipe was higher than that in horizontal pipe. The empirical expressions for predicting the oil retention amount and pressure drop were suggested. The mean absolute percentage errors of each expression for predicting the oil retention amount in horizontal and vertical pipes were 18.1% and 14.1%, respectively, and those for predicting the pressure drop in horizontal and vertical pipes were 22.2% and 20.1%, respectively.

Arijit Kundu et al. [2014] did an experimental study to investigate the characteristics of the flow boiling heat transfer for different fluid, namely, pure refrigerant (R134a), quasi-Azeotropic mixture (R410A) and Zeotropic mixture (R407C). The test section is a smooth horizontal tube (7.0 mm ID) uniformly heated by the resistance heating effect. The flow boiling characteristics of the refrigerants are evaluated varying: (i) the refrigerant mass velocities within the range 100–400 kgm−2s−1; (ii) the heat fluxes within 3.0–10.0 kWm−2; (iii) the inlet temperatures to the evaporator within 5°C-9°C. In this study, the effect on the heat transfer coefficient and two-phase pressure drop of vapor quality, mass velocity, imposed heat flux and fluid thermo-physical properties are examined in detail. Moreover, an assessment of predictive methods is provided for local heat transfer coefficients; also a direct comparison of flow regimes visualizations for refrigerants with a flow pattern map available in the literature is presented. Sandip P. chavhan et al.. [2013] presented a review of an alternative to R134a refrigerant in domestic refrigerator and also Listed different possible refrigerants. Mohd.Aasim Nazeer Ahmed Quraishi et al.. [2013] did a Study of use of Hydrocarbons and other blends as refrigerants.Nano particles were added to the refrigerant to improve the performance and to reduce the energy consumption. Akintunde,M.A et al.. [2013] conducted an Experimental study of R134a, R406A and R600a as alternative to Freon 12 where research is focused on refrigerant blends as alternatives to R12 only. According to Kandadai Srinivasan at al. [2013], the main theme of their paper is to study the flammability suppression of hydrocarbons by blending with carbon dioxide, and to evaluate these mixtures as possible working fluids in organic Rankine cycle for medium temperature concentrated solar power applications. The analysis takes into account inevitable irreversibilities in the turbine, the pump, and heat exchangers. While the isopentane + CO2 mixture suffers from high irreversibility mainly in the regenerator owing to a large temperature glide, the propane + CO2 mixture performs more or less the same as pure propane albeit with high cycle pressures.

Justin J et al. [2013] in their study, a finite volume, steady-state evaporator model that includes rectangular minichannel and microchannel tubes with louvered fins was developed and validated. The model was then used to compare the thermal-hydraulic performance of experimental ternary refrigerant mixtures to more traditional refrigerants — namely, R-125/R-143a/R-161 (45%/40%/15%) versus R-404a and R-125/R-32/R-161 (34%/15%/51%) versus R-22. R-125/R-143a/R-161 (45%/40%/15%) exhibited significantly higher heat transfer per unit area than R-404a with only a small accompanying increase in the refrigerant-side pressure drop for the cases studied. Similarly, R-125/R-32/R-161 (34%/15%/51%) exhibited significantly higher heat transfer per unit area than R-22 with a minimal difference in refrigerant-side pressure drop. Both refrigerant mixtures also possess lower global warming potentials (GWPs). Based on these criteria (i.e. increased thermal performance and reduced GWPs), both mixtures would serve as suitable replacements for R-404a and R-22 in applications where the slight flammability of these blends was not a concern. Chi-Chuan Wang et al. [2012] review provides an overview of the lubricant on the heat transfer performance, including nucleate boiling, convective boiling, shell side condensation, forced convective condensation, and gas cooling, for conventional refrigerants and natural refrigerant R-744. Various parameters affecting the heat transfer coefficient subject to lubricant, such as oil concentration, heat flux, mass flux, vapor quality, geometric configuration, saturation temperature, thermodynamic and transport properties are discussed in this overview. Linlin Wang et al. [2012] conducted an experiment to calculate Condensation heat transfer of low GWP refrigerant HFO1234yf in a horizontal tube (inner diameter: 4 mm) at a mass flux range of 100–400 $kg\ m^{-2}\ s^{-1}$ and different saturation temperatures (40, 45, and 50 °C), and the results were compared with that of R134a and R32. Effects of mass flux, vapor quality, saturation temperature, and thermophysical properties on the heat transfer coefficient were analyzed. A.S. Dalkilic et al. [2010] did a theoretical performance study on a traditional vapour-compression refrigeration system with refrigerant mixtures based on HFC134a, HFC152a, HFC32, HC290, HC1270, HC600, and HC600a was done for various ratios and their results are compared with CFC12, CFC22, and HFC134a as possible alternative replacements. In spite of the HC refrigerants' highly flammable characteristics, they are used in many applications, with attention being paid to the safety of the leakage from the system, as other refrigerants in recent years are not related with any effect on the depletion of the ozone layer and increase in global warming. 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. The effects of the main parameters of performance analysis such as refrigerant type, degree of subcooling, and superheating on the refrigerating effect, coefficient of performance and volumetric refrigeration capacity are also investigated for various evaporating temperatures. V. Vinš et al. [2010] did a detailed study of an unfavorable effect of gas impurities on the throttling process inside a small-diameter tube, i.e. a capillary tube. A special testing capillary tube equipped with precise temperature and pressure sensors has been used for an experimental investigation of the capillary flow of a saturated fluorocarbon refrigerant, R218, contaminated by dissolved nitrogen. The gas impurities significantly affected the throttling process, since the two-phase flow started notably earlier than in the case of pure refrigerant flow. Moreover, the gas contamination resulted in a decreased mass flow rate of refrigerant delivered through the capillary tube. A comprehensive numerical model has been developed to simulate the capillary flow of gas-contaminated refrigerant.

In Bukola Olalekan Bolajiet al. [2011] study, an experimental research was carried out to investigate the performance of R22 and its ozone-friendly alternative refrigerants (R404A and R507) in a window air-conditioner. The performance parameters of the system using R22 were considered as benchmarks and those obtained using alternative refrigerants were compared. Experimental results showed that R22 had the lowest pressure ratio and discharge temperature closely followed by R507. The average discharge temperature obtained using R507 and R404A were 4.2% and 15.3% higher than that of R22, respectively. The lowest compressor power and energy consumption were obtained from R507 retrofitted system. Also, the highest refrigeration capacity and coefficient of performance (COP) were obtained using R507 in the system. The average refrigeration capacities of R507 and R404A were 4.7% higher and 8.4% lower than that of R22, respectively, while the average COP of R507 increased by 10.6% and that of R404A reduced by 16.0% with respect to that of R22. According to T.S. Ravikumar et al. [2009] R134a has been accepted as the single major refrigerant in the automobile industry and it has been used worldwide. But, the problem associated with it is the use of the PAG oil as the lubricant. Unlike the conventional mineral oil, the synthetic PAG oil used with R134a is highly hygroscopic in nature. The PAG lubricants come with different additives unique for different compressors. This leads to serious service issues. Therefore, a refrigerant, which will be readily available to replace R12, and also compatible with mineral oil, is needed. In the present study the readily available R134a is used in place of R12. 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. The cool down performance under varying speed and varying ambient conditions, system performance under severe accelerating conditions and bumper-to-bumper traffic conditions is studied. The test results show that the new blend can be a promising substitute for the existing R12 systems and it can eliminate the use of hygroscopic PAG oil. Jiangtao Wu et al [2009] study reports a ternary blend R152a/R125/R32 with a mass ratio of 48/18/34 as a potential alternative to R22. A computer code has been developed with NIST REFPROP 7.0 for the comparative analysis of thermophysical properties and refrigerant performance of this new mixture and of R22. A drop-in test of this new mixture was performed in a domestic air-conditioner originally designed for R22. Both the calculation and experimental results showed that this new mixture could be regarded as a most likely drop-in substitute for R22 in many applications. The flammability of this ternary blend was also studied with an explosion apparatus to prove that it could be used safely. M. Mohanraja et al. [2009] reviewd the various experimental and theoretical studies carried out around the globe with environment friendly alternatives such as hydrocarbons (HC), hydroflurocarbons (HFC) and their mixtures, which are going to be the promising long-term alternatives. In addition, the technical difficulties of mixed refrigerants and future challenges of the alternatives are discussed. The problems pertaining to the usage of environment friendly refrigerants are also analyzed. James M. Calm et al [2008] reviews the progression of refrigerants, from early uses to the present, and then addresses future directions. The article breaks the history into four refrigerant generations based on defining selection criteria. It discusses displacement of earlier working fluids, with successive criteria, and how interest in some early refrigerants re-emerged, for example renewed interest in those now identified as "natural refrigerants." The paper examines the outlook for current options in the contexts of existing international agreements, including the Montreal and Kyoto Protocols to avert stratospheric ozone depletion and global climate change, respectively. It also examines other environmental concerns and further international and local control measures.

K. Mani et al [2008] Conducted an experimental performance study on a vapour compression refrigeration system with the new R290/R600a refrigerant mixture as drop-in replacement and 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. M.A.Sattar etal.. [2007] conducted Performance investigation of domestic refrigerator using pure hydrocarbons and blends of hydrocarbons as refrigerants. The COP for the HC's and blends of HC's are compared with the COP of HFC134a. Yunho Hwang et al [2007] provided a clear understanding of the relative performance potential of HFCs (R-404A and R-410A) as compared to R-290 for walk-in refrigeration systems representing direct expansion commercial refrigeration systems with small charge, and an experimental evaluation of the three refrigerants was investigated. To compare the environmental impact of refrigerants over the entire life cycle of fluid and equipment, including power consumption, the life cycle climate performance (LCCP) of the three refrigerants were evaluated based on measured data. The estimated LCCPs at various emission rates indicate that the LCCP of R-290 is always lower than that of R-404A. The LCCP of R-410A is lower than that of R-290 as long as the annual emission is kept below 10%. It was concluded that R-410A has less or equivalent environmental impact as compared to R-290 when safety (toxicity and flammability), environmental impact (climate change), cost and performance (capacity and COP) are considered. David C.Adams et al..[2006] Conducted an Experimental investigation of Two phase pressure drop of CO2,Ammonia and R245fa in Multiport Aluminum Micro channel Tubes. In D.D. Royal et al [2005] paper a method is presented for predicting the viscosity of liquid refrigerant mixtures. The method has no adjustable parameters and, in essence, relies upon the knowledge of the viscosity of the pure components to predict the viscosity of a mixture by means of kinetic theory and rigid-sphere formalism. The predictions have been compared with the available experimental data for a number of refrigerant mixtures. Based on this comparison and previous studies, the accuracy of the proposed method is assessed to be of the order of ±7%.

Neil A Roberts et al.. [2004] Presented laboratory results of energy saving refrigerant blends comprising R125, R134a, R600 or R600a. Blends R417A and 79 are suitable as replacements for R22,R402B,R408A,R502. Khalid A. Joudi[2003] did a computational model with the objective of simulating the performance of an ideal automotive air conditioning system, working with several refrigerants. The main function of this model was to determine the most suitable alternative refrigerant for R-12. Some assumptions about the losses and irreversibilities were embodied in this model for more realistic results. The effects of several parameters on system performance and compatibility were investigated, including evaporating temperature, condensing temperature and compressor rotational speed. Five refrigerants were studied by this model, including R-12, R-134a, R-290, R-600a and a mixture of propane and isobutane R290/R600a (62/38, molar percentage). The model predicted that the mixture (R290/R600a) was the most suitable alternative for R-12 and that several modifications should be performed when the other alternative refrigerants are used in the R-12 system. The major part of this work was an experimental investigation for the use of R290/R600a as a drop-in alternative for R-12 in a prototype automotive air conditioning system. Ninety-two (92) tests were conducted on both refrigerants to study the effect of four parameters on system performance. These were outdoor air temperature, cooling load, compressor rotational speed and the soaking temperature. Three outdoor air temperatures were considered, 35, 40 and 50 °C. Six rotational speeds were employed, 700, 1000, 1500, 2000, 2500 and 3000 rpm, whereas four cooling loads were simulated in the evaporator chamber, 1000, 2000, 3000 and 3500 W. The evaporator chamber was soaked at five temperatures, 45, 50, 55, 60 and 65 °C. Two types of tests were performed, including single operation mode tests and multi-operation modes tests. There was close similarity between the performance of the R290/R600a mixture and R-12 with superiority for R-12 in the working pressures, energy consumption and the COP values, whereas the mixture (R290/R600a) outperformed R-12 in the subcooling, superheating, evaporator discharge air temperature and the cooldown time. The results of this work showed good agreement with the experimental and theoretical results available in the literature. In his paper Gianfranco Angelino et al. [2003] has tested Five zero ODP (ozone depletion potential) hydro-fluorocarbon refrigerants (HFC-23, HFC-143a, HFC-227ea, HFC-236fa, HFC-245fa) to define their maximum usable temperature and their thermal degradation threshold. A. Cavallini et al. [2001] paper reports experimental heat transfer coefficients and pressure drops measured during condensation inside a smooth tube when operating with pure HFC refrigerants (R134a, R125, R236ea, R32) and the nearly azeotropic HFC refrigerant blend R410A. The experimental runs are carried out at a saturation temperature ranging between 30 and 50°C, and mass velocities varying from 100 to 750 kg/(m2 s), over the vapour quality range 0.15–0.85. The effects of vapour quality, mass velocity, saturation temperature and temperature difference between saturation and tube wall on the heat transfer coefficient are investigated by analysing the experimental data. A predictive study of the condensation flow patterns occurring during the tests is also presented A. Stegou-Sagia et al [2000] work reports that the Refrigerant mixtures may be used to solve the ozone layer depletion problem as they offer the optimum combination of favorable technical performance with environmentally acceptable behavior. Their work also reports the thermodynamic properties and characteristics of the binary mixtures R-32/R-134a in compositions 20–80%, 30–70%, 40–60% by mass and of the ternary mixture R-407c: 23 wt% R-32 + 25 wt% R-125 + 52 wt% R-134a. A computer code has been developed for the phase equilibrium relationship of the binary mixtures using related activity and fugacity coefficients. X. Boissieux et al. [2000] paper presents experimental heat transfer results obtained during the evaporation of Isceon 59, R407C and R404A in a horizontal tube. The results have been compared with existing correlations which characterizes the evaporative heat transfer coefficient to assess the validity of these models for refrigerant mixtures.

III. Conclusion

In the past, refrigerant blends have been based on chlorofluorocarbon (CFC), hydrochlorofluorocarbons (HCFC), and hydro fluorocarbon (HFC) refrigerants. However, because of ozone depletion potential (ODP) and global warming potential (GWP) regulations, most of today’s refrigerant blends are HFC-based and have zero ODP with small GWP impacts to the environment. Even though most of today’s blends are HFC-based, they can sometimes contain a small percentage of a hydrocarbon (HC) as a refrigerant. The HC, however, will not make the blend flammable because it only constitutes a small percentage usually less than 3 percent of the total refrigerant blend. Refrigerant blends have been carefully formulated and mathematically modeled to tailor their characteristics to match certain properties of the refrigerants they are replacing and to provide maximum system efficiency and performance. In some cases there could be a need to make some changes to the base systems while using blends. If the blends are non-azeotropic, i.e. the liquid and vapor composition is different at given temperatures and pressures causes concerns on composition changes in the refrigerant supply chain. The servicing procedure especially charging will be complicated because several of the blends use flammable hydrocarbons as one of the components and some blends just use a mixture of hydrocarbons. Usage of blends will also complicate the recovery or recycling programme due to the cross contamination as equipment with the blends might not be properly labeled or the technicians may just ignore the label. According to the Kyoto and Montreal protocols the harmful refrigerants have to be phased out with alternate environment friendly refrigerants. Optimum blend composition for maximum performance of the system has to be studied much. Research work for deciding the concentration of blends has to be undertaken to have better performance of the system.

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