

“A review on Thermodynamic Analysis of a Vapour Compression Refrigeration System using Hydrocarbon Refrigerants”

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Abstract – As per the recommendation from Montreal Protocol it was decided to initiate the worldwide phase out of CFCs and HCFCs. Moreover in Kyoto Protocol even new developed HFCs refrigerants like R-134a should be gradually phased out due to their high global warming potentials (1430). The present work is to explore performance evaluation of most appropriate drop-in replacements of with Zero ODP and low GWP R134a in domestic refrigerator refrigerants. The assessed refrigerants are R290, R600a, R430A, and R436A. Thermodynamic and transport properties of refrigerants are the most important factors in selection of the refrigerant's as they determine the performance of the system. The other important valuable characteristic of refrigerants are low liquid viscosity, high heat of vaporization, modest liquid density and slightly high gas density. In any refrigerant selection environmental characteristics of refrigerants are an also important criterion which gives their important thermodynamic behaviors.

Key Words: Thermodynamic Performance, Low GWP, Zero ODP, Drop in replacement, Hydrocarbon Refrigerants

1. INTRODUCTION

Hydro-chloro-fluoro-carbons and Chloro-fluo-carbons have been applied highly more as in refrigeration systems earlier due to their good safety properties. Many refrigerants are good in property and it gives high performance but due to harmful effect on ozone layer and due to environmental consideration it will not take in account. Many chloro fluoro carbons has good property but due to Montreal and Kyoto protocol that type of refrigerants phased out. Many hydrofluoro carbons are also had good extensive property but due to its high global warming potential it also phased out upto the year 1992. Due to greenhouse gases level which highly effect to ozone layer and destroyed protection cover for the earth. After in 1997 at Kyoto Protocol in which it was decide that which is also highly affect global warming ozone layer. So consequently it was decided to decrease global warming by reduction of greenhouse gases emissions. So due to this protocol new refrigerant which have also good thermal and transport property like R-134a should be continuously remove out due to their high global warming potentials. So by phase out that conventional refrigerants it was necessary to find new developed refrigerant have low

GWP and also low ODP. It is necessary to produce more environmental friendly and safe refrigerants such that it gives that the maximum energy efficiency.

1.1 Fluid Selection

For liquid choice in refrigeration and aerating and cooling frameworks determination of a legitimate working liquid is the most vital for a specific application. Low an unnatural weather change potential has been most critical attractive criteria of refrigerant's determination. Actually, natural qualities of refrigerants are turning into the predominant criteria gave that their thermodynamic practices and safeguards are positive also.

1.2 Environmental impact

The major main problems for common refrigerants is Environmental effects so that environmental friendly low GWP refrigerant, non-flammable and non-toxic refrigerants are necessary for refrigeration process. Ozone exhaustion potential (ODP) and a worldwide temperature alteration potential (GWP) are the important factors of refrigerants in case of any leakage or releasing to the surroundings.

1.3 Thermophysical properties

The desirable thermodynamic properties are a normal boiling point slightly less than target temperature and, thereby, an evaporating pressure higher than atmospheric pressure. The other favorable characteristics are, low liquid viscosity, high heat of vaporization, modest liquid density and slightly high gas density. It is worthwhile to mention that high heat of vaporization and gas density lead to higher capacity with a specific compressor in a refrigeration system. High liquid thermal conductivity intensifies heat transfer and results in smaller required heat exchangers. Low viscosity also causes low pressure drop in the heat exchangers. Smaller pressure ratio leads lower compression work and improve COP of the system.

2 LITERATURE SURVEY

K. Mani, V. Selladurai, et, al [1] they perform test execution contemplate on a vapor pressure refrigeration framework with the new R290/R600a refrigerant blend and contrasted and CFC12 and HFC134a. The vapor pressure refrigeration framework was at first dealt with the in view of refrigerant R12. Exploratory outcomes demonstrated indicated somewhat bring down refrigerating limit than R12. Blend R290 and R600a expended 6.8% to 17.4% more vitality than R12. The refrigerant R12 expended marginally more vitality than R134a at higher vanishing temperatures. The coefficient execution of R290/R600a blend increments from 3.9% to 25.1% than R12 at lower vanishing temperatures and 11.8% to 17.6% at higher dissipating temperatures. The refrigerant R134a gives somewhat bring down coefficient of execution than R12. The release temperature and release weight of the R290/R600a blend was closer to R12. The R290/R600a (68/32 by wt%) blend can be considered as a drop-in swap refrigerant for CFC12 and HFC134a.

Akhilesh Arora, S.C. Kaushik, et, al [2] In this paper point by point exergy examination of a genuine vapor pressure refrigeration (VCR) cycle was broke down. For ascertaining coefficient of execution (COP), exergy productivity, exergy pulverization and effectiveness deserts a computational model has been created for R502, R404A and R507A refrigerants. Examination and examination prepare has been accomplished for evaporator and condenser. Temperatures for evaporator and condenser are in the scope of - 50 °C to 0°C and 40 °C to 55°C, individually. The examination of results demonstrates that R507A is a superior substitute to R502 than R404A. In condenser the effectiveness deformity is most noteworthy, and least in fluid vapor warm exchanger.

M. Mohanraj, et, al [3] It speak to exploratory examination did by utilizing hydrocarbon refrigerant blend contain of R290 and R600a in the proportion of 45.2:54.8 by weight as an other option to R134a. Exploratory examination completed in a 200 l single evaporator local fridge. Nonstop running tests were performed under various encompassing temperatures for 24, 28, 32, 38 and 43 °C, while cycling running (ON/OFF) tests were done just at 32 °C surrounding temperature. The trial comes about demonstrated that the hydrocarbon blend has bring down estimations of vitality utilization; pull down time and ON time proportion. It gives additionally higher coefficient of execution (COP). The release temperature of hydrocarbon blend was observed to be additionally diminished than that of R134a. The general execution of result has presume that the best possible hydrocarbon refrigerant blend could be the best long haul other option to eliminate R134a.

Ahamed, R. Saidur, J.U. H.H. Masjuki, et, al [4] In this paper surveys of looks into in the field of exergy examination in different segments and in usable divisions where vapor pressure refrigeration frameworks are utilized. From the point by point perception it was found that exergy relies on upon dissipating temperature, consolidating temperature, sub-cooling and compressor weight. Exergy likewise relies on upon ecological encompassing temperature. Hydrocarbons

are considered as new created refrigerant having low ODP and GWP, and on that sort of refrigerants chose by the scientist to investigation of that vitality and exergy examination. Diverse hydrocarbon refrigerants like R407a, R 600a, R 410a and R 290, R600 and their fitting blends are considered and broke down as for vitality and exergy effectiveness. Diverse hydro carbon blends with R134a additionally indicate better execution concerning different refrigerants. Generally investigated by specialist that the real piece of exergy misfortunes is happened in the compressor. Many research demonstrated that Nanofluid and nanolubricant which adequately to decrease the exergy misfortunes in the compressor in a roundabout way.

Mahmood Mastani Joybari, et, al [5] worked on analysis of exergy for the domestic refrigerator which originally manufactured for R134a. On the basis of the investigation In this paper surveys of investigates in the field of exergy examination in different parts and in usable divisions where vapor pressure refrigeration frameworks are utilized. From the point by point perception it was shows that exergy relies on upon vanishing temperature, gathering temperature, sub-cooling and compressor found that the most extreme exergy pulverization happened in the compressor. Exergy devastation accordingly decreased in different parts like condenser, slender tube, evaporator, and superheating loop. In that investigation Taguchi technique was utilized. Taguchi strategy was helpful for to limit exergy devastation. From consequence of R134a Taguchi parameters were chosen and an investigation utilizing 60 g of R600a, which gives comparable outcomes as R134a. As per the aftereffect of R134a parameters of a R600a like charge sum, condenser fan speed, compressor and coefficient of execution were chosen for the plan. From the outcome investigation charge measure of R600a was the most essential parameter. Legitimate measure of charge gives financial points of interest, and furthermore decreased the danger of combustibility of the hydrocarbon refrigerant. Exergy likewise relies on upon ecological encompassing temperature. On that kind of refrigerants chose by the specialist to investigation of that vitality and exergy examination. Distinctive hydrocarbon refrigerants like R407a, R 600a, R 410a and R 290, R600 and their proper blends are considered and investigated as for vitality and exergy effectiveness. Diverse hydro carbon blends with R134a additionally indicate better execution as for different refrigerants. For the most part examined by analyst that the significant piece of exergy misfortunes is happened in the compressor. Many research demonstrated that Nanofluid and nanolubricant which adequately to diminish reduced friction loss.

Joel Boeng, Claudio Melo, et, al [6] worked on the behavior of a household refrigerator. In which experimental thermodynamic analysis was performed. In that experiments simultaneously changing the refrigerant charge and the development limitation test perform. Appropriate charging gadget was planned and developed; the first hair like tube was supplanted with a bigger measurement slim tube and orchestrated in arrangement with a legitimate control valve. The extension confinement was fluctuated by conforming the valve game plan. By legitimate blends of refrigerant charge

and development limitation greatest work ought to be acquired. It was additionally broke down that a legitimate blend lessened vitality utilization, while dishonorable mix of extension confinement and refrigerant charge may build the vitality utilization.

C. Aprea, A. Greco, et, al [7] In this paper relative exergetic examination, completed with exploratory tests. Examination worked performed amongst R134a and common refrigerant liquid R744 (CO₂). R134a is a hydrofluorocarbon with a high an Earth-wide temperature boost affect (GWP), while the R744 less an unnatural weather change affect. This paper looks at R134a refrigeration plant and a model R744 framework which working in a trans-basic cycle. In the test an exergetic investigation has been completed for all segments and on the general plant. The outcome broke down from the analysis that the general exergetic exhibitions of the vapor pressure plant chipped away at R134a are reliably superior to that of R744 that distinction is from at least 20 to a greatest of 44 %. In the trial worked the execution of the individual parts of the plant has been investigated, with a specific end goal to pinpoint which contributing most to the reduction in the exergetic execution of R744.

M. Mohanraj, et, al [8] has present work on the theoretically energy performance of a domestic refrigerator with R134a and R430A as option refrigerant. In that the execution has been completed for with an extensive variety of evaporator temperatures amongst -30 and 0 °C and three diverse consolidating temperatures, particularly, 40, 50 and 60 °C. The test execution of the household fridge was looked at regarding compressor control utilization coefficient of execution, volumetric cooling limit, and compressor release temperature. The examination from the outcome demonstrated that volumetric cooling limit comparable. Furthermore on the premise of 15-year time skyline add up to equal an Earth-wide temperature boost effect of the fridge was measured for examination. Because of its higher vitality proficiency add up to equal a worldwide temperature alteration effect of R430A was showed to be smaller than that of R134a by around 7%. The outcomes from the test examination affirmed that R430A is a vitality proficient and condition neighborly contrasting option to R134a in local coolers.

M. Rasti, et, al [9] which demonstrate a trial examination of substituting R134a with R436A which is a blend of R290 and R600a with a mass proportion of 56/44. Analyze performed on a solitary evaporator local cooler with gross volume 238 L without no any adjustment in refrigeration cycle. The fridge's energy utilization amid operation and the temperatures in various areas of the icebox were measured. Notwithstanding fridge's compressor was accused of various measure of R436A. Test comes about demonstrated that in contrast with the base cooler working with R134a, the ON time proportion and the vitality utilization every day were lessened by 13% and 5.3%, individually. In spite of the fact that the initially R134a charge for this cooler was 105 g, then again for R436A was lessened to 55 g. That demonstrated that 48% diminishment in refrigerant charge it additionally lessened fire risk.

Hilmi Cenk Bayrakci, Arif Emre Ozgur, et, al [10] In this theoretical analysis think about, four distinctive unadulterated HCs propane (R290), butane (R600), isobutane (R600a) and isopentane (R1270) are broke down. In this hypothetical review speak to a correlation of vigorous and exergetic execution of a vapor pressure refrigeration framework utilizing immaculate hydrocarbon (HC) refrigerants. For base perusing in that hypothetical investigation R22 and R134a are likewise utilized. Comes about have been exhibited graphically. As per results, it has not more contrasts of coefficient of cooling execution estimations of these refrigerants. In an exergetic proficiency and enthusiastic qualities got with R1270 and R600 are higher than R600a and R290.

Mohamed El-Morsi, et, al [11] In this theoretical analysis study done on three distinctive immaculate HCs propane (R290), butane (R600) and business LPG (condensed oil gas). In that hypothetical investigation shows an examination of enthusiastic and exergetic execution of a vapor pressure refrigeration framework utilizing immaculate hydrocarbon refrigerants. R134a is likewise utilized as a part of the investigation as a source of perspective refrigerant for examination and correlation. Proper method chose for investigation. For unraveling the thermodynamic conditions, MATLAB programming is utilized while the thermo-physical properties are ascertained utilizing REFPROP programming. The consequences of that hypothetical review was R600 has the most noteworthy COP and exergetic effectiveness, while LPG has the least. Investigation result contrasted with R134a, then it was found that the COP for R134a is higher than that for LPG by 10%. Likewise, the exergetic productivity is 5% higher than that of R134a. In that examination imperative to note that LPG has being not costly, and accessible in vast sums. While in another hand natural effect is zero ozone consumption potential and low a worldwide temperature alteration potential.

Miguel Padilla, Remi Revellin, Jocelyn Bonjour, et, al [12] In this test work to investigate that exergy examination finished with the zeotropic blend R413A. test examination done on a local vapor-pressure refrigeration framework which initially intended to work with R12 refrigerant. Elements influencing the execution of both refrigerants R12 and R413a are assessed utilizing an exergy examination. Test tests are done in a controlled situation. Test perusing completed for the chose test information infer that the general vitality and exergy execution of the framework working with refrigerant R413A which is higher than that of R12.

Mehdi Rasti, SeyedFoad Aghamiri, Mohammad-Sadegh Hatamipour, et, al [13] In that investigations are done on an icebox which was produced for 105 g R134a refrigerant charge. In the test the powerful factors including like refrigerant sort, refrigerant charge and compressor sort are watched. This examination is led utilizing refrigerant R436A which blend of 46% iso-butane and 54% propane and R600a which was unadulterated iso-butane utilized as hydrocarbon refrigerants. In that examination HFC sort compressor which is intended for R134a and HC sort compressor which is intended for R600a are utilized. From the exploratory

outcomes demonstrate for R436A and 55 g for R600a individually. What's more, for this kind of compressor, the vitality utilization of R436A and R600a is lessened around 14% and 7% at the ideal charges, individually in contrast with R134a. While then again, when utilizing HC sort compressor, refrigerant charges are diminished around 14.6% and 18.7%, separately. From the trial result it was dissected that aggregate exergy demolition of the residential icebox, individually.

3. CONCLUSIONS

By reviewing all these research work and by observing various thermodynamic properties of the refrigerants and as per environmental protocols like Montreal and Kyoto conventions, R12 refrigerant which is as of now eliminated and the lessened the utilization of refrigerant R134a because of its high a worldwide temperature alteration potential, and its creation is shut everything down in 2040. Then again R290, R600a and its mixes like R430A, R436A and some recently created hydrocarbon refrigerants are the better alternative for the set up of R134a in household icebox, was necessary to find new developed refrigerant have low GWP and also low ODP. It is necessary to produce more environmental friendly and safe refrigerants such that it gives that the maximum energy efficiency. Compare the performances with the R134a, several combinations of different length and bore for capillary, proper highly efficient instrument like compressor, condenser, evaporator and expansion valve arrangement cop and exergy efficiency of the system are increased. Proper selection of the refrigerant for particular compressor as well as charging amount is also an important factor. By different charge amount and varying an expansion restriction to optimize energy consumption for the system.

ACKNOWLEDGEMENT

I express my gratitude to my guide Prof. Hussain Pipwala for his expert guidance, encouragement and suggestion.

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