Performance on Domestic Refrigerator by Using Eco-Friendly Refrigerent- A Review

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Abstract- The depletion of ozone layer and green house effects are worldwide problem. Refrigerants also part of these as it is source of depletion of ozone layer. For this we are going to use eco-friendly refrigerant in place of conventional CFC(chloroflorocarbon) eco-friendly refrigerant are less harmful for environment. Purpose of this experiment is to find the effect produce by different refrigerant in the domestic refrigerator system. This study deals with domestic refrigerator designed to work with three different refrigerant R-410, R-134A, R-404A along with desert cooler .here, comparative analysis is going to be done by using above three refrigerant. In this we are going to use hot water from overhead tank and this hot water is cooled in desert cooler then this water is circulated in water jacket used to subcool the refrigerant. As we know COP of domestic refrigerator in winter is higher than summer so we will use high temperature summer water and try to improve COP and reduction in power consumption.

Keywords-COP,R-134A,R-410,R-404A,coolingjacket, refrigerator, desert cooler.

1. INTRODUCTION

Refrigeration is a process of removing heat from a low-temperature reservoir and transferring it to a high-temperature reservoir. In a refrigerating system, the medium of heat transfer which picks up heat by evaporating at a low temperature and pressure, and gives up heat on condensing at a higher temperature & pressure. A fluid used for heat transfer in a refrigerating system which absorbs heat at a low temperature and low pressure of the fluid and transfers heat at a higher temperature and higher pressure of the fluid, usually involving changes of state of the fluid called as refrigerant. Early mechanical refrigeration systems employed sulfur dioxide, methyl chloride and ammonia. Being toxic, sulfur dioxide and methyl chloride rapidly disappeared from the market with the introduction of CFCs. Occasionally, one may encounter older machines with methyl formate, chloromethane or dichloromethane.

Chlorofluorocarbons were little used for refrigeration until better synthesis methods, developed in the 1950s, reduced their cost. Their domination of the market was called into question in the 1980s by concerns about depletion of the ozone layer. now a days we are using different like CFC(ChloroFluoroCarbons),FC(fluorocarbon), HF(hydrofluorocarbon).

1.1 Properties Of Ecofriendly Refrigerent

- Vapour density To enable use of smaller compressors and other equipment the refrigerant should have smaller vapour density.

-Enthalpy of vaporization
-Thermal Conductivity
-Dielectric strength
-Critical temperature
-Specific heat
-Leak tendency
-Toxicity

R-410A

R-410A was invented and patented by Allied Signal in 1991. Unlike alkyl halide refrigerants that contain bromine or chlorine, R-410A (which contains only fluorine) does not contribute to ozone depletion, and is therefore becoming more widely used, as ozone-depleting refrigerants like R-22 are phased out. However, it has a high global warming potential (1700 times the effect of carbon dioxide), similar to that of R-22. Since R-410A allows for higher SEER ratings than an R-22 system, by reducing power consumption, the overall impact on global warming of R-410A systems will be substantially lower than that of R-22 systems due to reduced greenhouse gas emissions from power plants.

R-134A

R134a is also known as Tetrafluoroethane (CF3CH2F) from the family of HFC refrigerant. With the discovery of the damaging effect of CFCs and HCFCs refrigerants to the ozone layer, the HFC family of refrigerant has been widely used as their replacement. It is now being used as a replacement for R-12 CFC refrigerant in the area of centrifugal, rotary screw, scroll and reciprocating compresssors. It is safe for normal

handling as it is non-toxic, non-flammable and non-corrosive. It exists in gas form when expose to the environment as the boiling temperature is -14.9°F or -26.1°C.

R-404A

R-404A is a blend refrigerant developed as a substitute for R-502 (HCFC/CFC blend refrigerant) which has been widely used for commercial-use refrigeration equipment. It is a mixture of HFC-125, HFC-143a, and HFC-134a, and is a pseudo-azeotropic refrigerant. It requires liquid filling to prevent change in composition Refrigerant Gas R404A is a blend of CF3CHF2 (R-125, 44% by mass), CF3CH3 (R-143A, 52%) and CH2FCF3 (R-134A, 4%). Non-combustible, but toxic gases can be produced by thermal decomposition in a fire.

2. LITERATURE REVIEW

A study was conducted in 2017 on the 2nd annual applied science and engineering conference (AASEC) on the "Expansion Parallel Liquid Refrigerant On A Vapour Compression Systems With R-290" in which their aims to determine the performance improvement of a vapor compression systems that use expansion parallel liquid refrigerant. The experiment was conducted by replacing the single expansion device with a parallel expansion device on a vapour compression systems. The working fluid is used as a cooling medium is R-290. By this we come to know "The results indicate that expansion parallel liquid refrigerant on the vapour compression systems generates an increased 49% value of the refrigerating effect and 2,5% value of the coefficient of performance (COP) so that it implicates for save on power consumption required a vapour compression systems".[1]

A paper was presented in International Conference on Recent Advancement in Air Conditioning and Refrigeration in November 2016 on "Empirical correlation based models for estimation of air cooled and water cooled condenser's performance", in this paper An experimental investigation was carried out in order to validate the predicted performance data of air cooled and water cooled condensers (using R134a as a refrigerant) from the developed correlation models. The heat rejection capacity is used as a performance indicator for mentioned condensers. By this study we come to know that The correlation based models developed in the present study can be extended to any practical applications for continuous online monitoring of the performance of the condensers and also for comparing the performance of the condensers manufactured by different industries. The performance analysis presented in this can be used as a reference tool for estimating the condenser performance of both air cooled and water cooled condensers. [2].

A analysis in done in august 2017 on "Analysis on maximum internal heat recovery of a mass-coupled two stage ammonia water absorption refrigeration system". Two sets of freezing conditions are assumed to carry out the analysis. The minimum system heat input and the relevant heat matching are determined by problem table method and grid method. the feasible system configurations with optimal energy target are presented under the set conditions according to the grid diagram.. by this paper we come to know that "The key point of the maximum internal heat recovery is the heat matching of the streams in the adjacent temperature intervals of the pinch point. Compared to a conventional mass-coupled two stage NH_3-H_2O absorption refrigeration system, the thermal COP of the derived system could be improved by 14.5% and 34.1% under the studied two sets of conditions. The improvement is more effective when there is a temperature overlap between the generation and absorption processes. The pinch analysis is valid on maximum internal heat recovery of a mass-coupled two stage ammonia-water absorption refrigeration system, providing not only the system performance but also the system configuration".[3]

A study was conducted in february 2017 on "novel ammonia-water combined power and refrigeration cycle with two different cooling temperature levels". A new ammonia-water cogeneration system is proposed to produce power and refrigeration outputs simultaneously, which combines Kalina power cycle and ejector refrigeration cycle. This cycle has two evaporators that can produce refrigeration output in two different temperature levels and capacities, in which the first evaporator pressure may be selected independently. Power to cooling ratio in this novel cycle can be adjusted. The effect of key parameters on the cycle performance have been investigated. by this study we concluded "The effect of key parameters such as turbine inlet pressure, heat source temperature, condenser temperature, cooling temperature and basic working solution ammonia concentration on the cycle performance shown that these parameters have a large effect on the cycle performance. [4]

A study was conducted in july 2015 on "Evaluation on environment-friendly refrigerants with similar normal boiling points in ejector refrigeration system" Which was Based on the "hypothetical throat area" theory and the "constant-pressure mixing" theory, a thermodynamic model for ejector was set up by introducing the real properties of refrigerants. In this paper, eight environment-friendly refrigerants were divided into 4 pairs for study according to their normal boiling point. by this study we got following conclusion 1-For refrigerants which have similar normal boiling points with each other, the one whose specific enthalpy of the primary flow is bigger commonly has the higher entrainment ratio of ejector.2-The operation conditions do not influence obviously the COP orders of refrigerants which have similar nor-mal boiling points with each other, although the whole order of COP of these eight refrigerants is altered. 3-For any two refrigerants, the closer the two lines of the saturated vapour pressures are, the smaller the difference in the pump power. .[5]

A paper was presented in The 7th International Conference on Applied Energy (ICAE) in 2015 on "An experimental investigation of condensation heat transfer

coefficient using R-410A in horizontal circular tubes", in this study Condensation heat transfer coefficient has been evaluated experimentally on the tube side of three different circular tubes with inner diameter of 6.61, 7.5 and 9.2mm, respectively. Two-phase fluid flow conditions include mass fluxes from 200 to 320kg/m2s, qualities between 0.1 to 0.9, and heat flux range from 5 to 20kW/m2 at a fixed saturation temperature of 48'C. by this we concluded " that the average heat transfer coefficient increased with the increase of vapor quality, mass flux and heat flux, but decreased with inner diameter. The data show that the condensation heat transfer coefficient increase with increasing mass velocity and vapor quality. The effect of mass flux on the heat transfer coefficient suggests that the contribution of forced convective heat transfer is dominant". [6].

A study was conducted in December 2015 on "heat and cold storage using phase change material in domestic refrigeration system" in which they presented review of experimental efforts as well as modelling approach to study the application of phase change material in the domestic refrigeration. Advantage and disadvantage of each type of storage is presented and future application is discussed. In this study they given reduction of the temperature fluctuation and enhancement of the system performance is the main reason of using phase change materials in refrigeration systems. Different approaches have been used to improve the thermal performance of these systems by integration of phase change material . A number of studies have been focused on the application of phase change material at evaporator for cold storage. By this comprehensive review of phase change material on domestic refrigeration system we come to know that "result were promising but still some modifications required by changing the different phase change material and finding the most suitable phase change material in order to get better results".[7]

A comparative study was conducted on january 2014 on "comparative study on ejector-expansion vapour compression refrigeration cycles for applications in domestic refrigerator-freezers. The present study aims to provide a deep insight into ejector-expansion vapour compression refrigeration cycles and contribute to the development of ejector expansion refrigeration technologies in domestic refrigeration. Four ejector-expansion vapour-compression refrigeration cycles (EVRs) are summarized. A novel MEVRC (modified EVRC) with a two-phase ejector is proposed. A mathematical model is developed to carry out comparative studies for mentioned EVRCs. This paper summarizes the existing EVRCs for promising applications in domestic refrigerator-freezers. Considering the limited capacity of the existing EVRCs to enhance cycle performance. By this study we knew that "The simulation results have indicated that MEVRC can perform much better in COP, volumetric refrigeration capacity and pressure lift ratio compared with other EVRCs and VRC at all given operating conditions due to the maximum expansion work recovery potential provided by the two-phase ejector in MEVRC".[8]

A paper was presented in February 2013 on "Ozone depletion and global warming Case for the use of natural refrigerant – a review" in this paper they presents natural refrigerants as the ideal, environmentally friendly refrigerants and the ultimate solution to the problems of ozone depletion and global warming. HFC refrigerants are currently the leading replacement for CFC and HCFC refrigerants in refrigeration and air-conditioning systems. This paper also analyses potentials of various natural refrigerants and their areas of application in refrigeration and air-conditioning systems. Natural refrigerants especially hydrocarbons and their mixtures are miscible with both mineral oil used in R12 and polyester oils used in R134a systems. Also, with exception of ammonia, they are fully compatible with all materials traditionally used in refrigeration systems Conclusion of this study was that "It provides strong basis for the need to embrace the use of natural refrigerants as replacement for the halocarbon refrigerants. Natural refrigerants especially hydrocarbons and their mixtures are miscible with both mineral oil used in CFC and polyester oils used in HFC systems. Also, with exception of ammonia, they are fully compatible with all materials tradition-ally used in refrigeration systems. Finally, this paper has revealed that natural refrigerants are the most suitable long time alter-natives in refrigeration and air-conditioning systems".[9]

A paper was presented in 2008 on "Performance of a new refrigeration cycle using refrigerant mixture R32/R134a for residential air-conditioner applications" In this paper, a new refrigeration cycle (NRC) using the binary non-azeotropic refrigerant mixture R32/R134a is presented, which can be an alternative refrigeration cycle applied in residential air-conditioner.. By this we concluded that "In the conventional refrigeration cycle (CRC), the mixture R32/R134a has a close performance to that is obtainable with pure refrigerant R22. However, the mixture R32/R134a in the NRC will result in a better performance. The maximum COP can be improved in the range of 8–9% over that of the CRC, and the volumetric refrigerating capacity increase by approximately 9.5%. The subcooling and superheating have great effect on the cycle performance, and the effect of the subcooling is much more than the superheating".[10]

An experimental study was conducted on march 2002 on "assessment of LPG as a possible alternative of R-12 in domestic refrigerators". in which experimental results on the performance of liquefied petroleum gas (LPG) as a possible substitute for refrigerant R-12 in domestic refrigerators are presented. Various mass charges of 50, 80 and 100 g of LPG were used during this study. The results show that LPG compares very well to R-12. The performance of LPG as a possible alternative to R-12 was studied experimentally. By this study we come to know that "The refrigerator worked satisfactory with LPG without making any modification to the machine. The COP values were comparable to those of R-12,

and in some instances, they were even higher than those of R-12. No operating problems were encountered with the refrigerator compressor and no degradation of lubricating oil was detected. The cooling capacities were higher for LPG than those of R-12. The only problem that can be associated with LPG is that it is a flammable substance and must be handled with caution".[11]

An experiment was performed in 1994 on "To find test result of hydrocarbon mixtures in domestic refrigerators/freezers" in which In the first part of the present research, an R290/R600 mixture was tested as a drop-in substitute in a 20-cubic-feet, single-evaporator, auto defrost, top mount, conventional domestic refrigerator/freezer. All the hardware remained the same, only the capillary tube was lengthened to achieve the optimum performance. The best result with an optimized R290/R600 blend was 6% savings compared to the baseline test with R12. In the second part of the research, an 18.0 cubic-feet, auto defrost, top mount, domestic refrigerator was used for experiment . by this experiment we come on conclusion that "the hydrocarbon blend R290/R600 is an attractive substitute for R12. In drop in test savings of upto6.5% could be achieved with a mixture composition 70/30 and 70 grams of charge. And this also says 14.6% and 16.7%energy savings in the refrigeration cycle. If we use ternary mixture (R190/R600/nc-5) it will give better performance than binary mixture"[12]

3.CONCLUSION

From the above literature review we knew that "expansion parallel liquid refrigerant on a vapour compression systems generates an increase in refrigerating effect and COP of 49% and 25% respectively. Modified ejector-expansion vapour compression refrigeration can perform much better in COP, volumetric refrigeration capacity and pressure lift ratio compared with other ejector-expansion vapour compression refrigeration(EVRCs) at all given operating conditions due to the maximum expansion work recovery potential provided by the two-phase ejector in modified ejector-expansion vapour compression refrigeration. The pinch analysis is valid on maximum internal heat recovery of a mass-coupled two stage ammonia-water absorption refrigeration system, providing not only the system performance but also the system configuration. The subcooling and superheating have great effect on the cycle performance, and the effect of the subcooling is much more than the superheating. on domestic refrigeration system we come to know that some modifications required by changing the different phase change material and finding the most suitable phase change material in order to get better results."

REFERENCES

[1] D Supriawan, ET Berman, M Komar" Expansion Parallel Liquid Refrigerant On A Vapor Compression Systems With R-290",Vol.59,Iss.7,July 2015, page 365–375.

[2] B. Kiran Naika, P. Muthukumara, "Empirical correlation based models for estimation of air cooled and water cooled condenser's performance", International Conference on Recent Advancement in Air Conditioning and Refrigeration, Energy Procedia 109 (2017) 293 – 305, 2016.

[3] S.Du ,R.Z.Wang, X.Chen," Analysis on maximum internal heat recovery of a mass-coupled two stage ammonia water absorption refrigeration system "Volume 133,issue 15 August 2017, Pages 822-831.

[4] Orbe lBarkhordarian, Ali Behbahaninia, Rasool Bahrampoury," A novel ammonia-water combined power and refrigeration cycle with two different cooling temperature levels" Volume 120, issue 1 February 2017, Pages 816-826.

[5] F. Wang,S.Q.Shen, D. Y. Li," Evaluation on environment-friendly refrigerants with similar normal boiling points in ejector refrigeration system "Vol.51, Iss.7,July 2015, page 965–972.

[6] Pham Quang Vua, Choi Kwang-Ilb, Oh Jong-Taekb, Cho Honggic, Kim Taehum ,Kim Junghoc, Choi Jaeyoungc, "An experimental investigation of condensation heat transfer coefficient using R-410A in horizontal circ 8ular tubes", The 7th International Conference on Applied Energy (ICAE) in 2015, Energy Procedia 75 (2015) 3113 – 311,2015.

[7] MahmoodMastani, Joybari , [a]FariborzHaghighat, [a]JeffMoffat [b]paulsra "Heat and cold storage using phase change materials in domestic refrigeration systems:The state-of-the-art review " Vol.106, 1 November 2015, Pages 111-124.

[8] XiaoWang , JianlinYu, MengliuZhou , Xiaolong," Comparative studies of ejector-expansion vapor compression refrigeration cycles for applications in domestic refrigerator-freezers" Department of Refrigeration & Cryogenic Engineering, School of Energy and Power Engineering, Xi'an Jiaotong University, Xi'an 710049, China, Volume 70 issue 1 June 2014 Pages 635-642.

[9] B.O.Bolajia Z.Huanb," Ozone depletion and global warming: Case for the use of natural refrigerant – a review "Vol.8, February 2013, Pages 49-54.

[10] Jianyong, ChenJianlinYu, **"**Performance of a new refrigeration cycle using refrigerant mixture R32/R134a for residential air-conditioner applications**"** Volume 40, Issue 11, 2008, Pages 2022-2027.

[11] Bilal AAkash,[a]Salem ASaid[b] **"**Assessment of LPG as a possible alternative to R-12 in domestic refrigerators "Volume 44, Issue 3, February 2003, Pages 381-388

[12] Z Liu, I Haider, BY Liu " Test results of hydrocarbon mixtures in domestic refrigerators/freezers" Volume 53, Issue 7 July1994, , page 912–932.