A Study of Performance Analysis of Vapors Compression Refrigeration System with Different Refrigerants

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Abstract **- Millions of refrigeration system is domestic refrigerator & air conditionings operating with R134a & R404A all over the world have to retrofit suitably in the event of the phase out due to high global warming potential like, 1400, 3260.**

HC mixture is an substitute refrigerant of hydro fluorocarbon (HFC) and chlorofluorocarbon (CFC) compound due to their lower GWP and zero ozone depletion potential (ODP), the effect on the environment is also reduce due to uses of hydrocarbon mixture in different mass ratio . Refrigeranthave been experimental performance analysis of the refrigeration system. used such as R134a & R404AR1270, R290 and CARE-30(Blend Mixture of R600a&R290). Few researcher has been prove that the refrigerant R134a,R404A,CARE30and(R1270 (50%) +R290 (50%))used in hermetically sealed compressor with the help of REFPROF software which define the property of the refrigerant and blend mixture of refrigerant. We are going to experimentally analysis with the help of U-RIG TEST (SVCR) for the mixture of following hydro fluorocarbon (HFC)&Hydrocarbon (HC) Refrigerant.

i) R134a
ii) R404A ((R125 (44%) R143a (52%), R134a (4%))
iii) (R1270 (50%) &R290 (50%))
iv) CARE-30 (R600a (50%) &R290 (50%))

Many performance measure like a compressor discharge temperature, pressure ratio, volumetric cooling capacity, volumetric efficiency, and mass flow rate are examined, the performance in term of coefficient of performance (COP) ,refrigerating capacity and compressor work to evaluated for the investigating refrigerant at various evaporating and condensing temperature

IndexTerms **-Refrigerant, R134a, R404A, R600a, R1270, R290, ODP, GWP, U-RIG TEST.**

I. **Introductio**n

Vapour compression refrigeration system is a system which is used to transfer heat from low temperature reservoir to high temperature reservoir with the help of working fluid, called refrigerant. There are different types of refrigerant, which were used as the working medium in vapors compression refrigeration system in the last few decades, but they cause of ozone layer depletion and green house effect. [1] The R134a has zero ODP but it has relatively high global warming potential. Hence there is a need to identify alternative refrigerant for replacement of R134a. On more investigation experimentally use of hydrocarbon refrigerant mixture R290 and R600a are used as an alternative refrigerant to R134a in domestic refrigerator [2].The last seven decades, the CFCs and HCFCs have been used in the field of refrigeration and air conditioning due to their favorable characteristics. As per the agreement of Montreal and Kyoto protocol 1987 all CFC'S and HCFC'S must be phased out both in developed and developing countries. As per ASHRAE standard 34 all HCFC should be phased out by 2030 .The Govt. of India, The Ministry of Environment and Forest (MoEF), emphasizing and giving indications on Environmental Impact Assessment (EIA).

The Ministry has issued the Environmental Impact Assessment Notification, 2006, which makes environmental clearance mandatory for the development activities to identify, examine, assess and evaluate the likely and probable impacts of a proposed project (alternate refrigerants) on the environment and, thereby, to work out remedial action plans to minimize adverse impact on the environment. Usage of natural refrigerants for Air conditioning system may be a best option for effective utilization for eco-friendly atmosphere. Current research focus on development of new refrigerants to retrofit the existing R134a systems. Various alternative refrigerants are available to the conventional systems. But each one has its own merits and demerits. A theoretical analysis was implemented for the use of R134a, propane (R290) and selected mixtures of R290/R600a 60 % / 40 %, R290/R600a/R134a 40 %/30%/30% and R290/R600a 50%/50% in the ASHRAE standard cycle cooling (evaporation temperature: -23.3ºC, condensation temperature: 54.4°C, temperature of liquid and suction: 32.2ºC) using the thermodynamic properties of REFPROP 6.0, as recommended by Kim. The coefficient of performance of systems for commercial and domestic refrigeration is increased from 10 to 20% when using mixtures of hydrocarbons containing R600a and R290 Sekhar [3]

Refrigeration finds its major application in domestic, commercial, industrial, transport and Food preservation and pharmaceutical industries. Due to the phase out of CFC which was responsible for major ozone depletion and global warming are now being

replaced by substitutes which are friendly to the environment. of R404a is Zeotropic refrigerant blend of R125/143a/134a (44, 52, 4%) which can be a suitable alternate for R134 a, R410a and CFC R502 Zeotropic refrigerants therefore do not boil at constant temperatures unlike Zeotropic refrigerants. Any substitute should generally possess some ideal properties like non flammability, non toxic, friendly to the natural environment, stable at all operating conditions and have similar characteristics of the refrigerant for which Hydro Flouro Carbons (HFC's) and its blends of refrigerants such as zeotropes are finding its applications in most of the commercial refrigeration sector as alternatesubstitutes and are cost effective Li and Zhao (2008)[7]

Refrigerant

The working fluid used to transfer the heat from low temperature reservoir to high temperature reservoir is called refrigerant. There are different types of refrigerant which are described as followings. CFC: They are molecules composed of carbon, chlorine and fluorine. They are stable, allowing them to reach the stratosphere without too many problems. It contributes to the destruction of the ozone layer. These are R11, R12, R113, R500, R502 etc. HCFC: They are molecules composed of carbon, chlorine, fluorine and hydrogen. They are less stable than CFCs, destroy ozone and to a lesser extent. These are R22, R123, R124, R401a etc. HFC: They are molecules composed of carbon, fluorine and hydrogen. They do not contain chlorine and therefore do not participate in the destruction of the ozone layer. This is known as substitution substance. Restrictions on this family of gas are currently limited. Within the European Union, the HFC will be banned from air conditioners for cars from 2011.These are R134a.

1. **Mixture of refrigerants**: They can be classified according to the type of fluorinated components they contain. They are also distinguished by the fact that some mixtures are:
- Zoetrope: in a state change (condensation, evaporation), the temperature varies. These are R404a, R407a and R410a etc.
- Azeotropes: they behave like pure, with no change in temperature during the change of state. These are R500, R502 and R507a etc.

2. Ammonia (NH3) or R717: Fluid inorganic thermodynamically is an excellent refrigerant for evaporation temperatures between - 35 °C to 2 °C. But it is a fluid dangerous toxic and flammable, so it is generally used in industrial refrigeration.
3. Hydrocarbons (HC) as R290, R600a: This is primarily propane (R290), butane (R600) and isobutene (R600a). These fluids have good thermodynamic properties, but are dangerous because of their flammability. The world of the cold has always been wary of these fluids, even if they have reappeared recently in refrigerators and insulating foams. Their future use in air conditioning seems unlikely, given the cost of setting both mechanical and electrical safety.
4. Carbon dioxide (CO2) or R744: This is inorganic, non-toxic, non flammable, but inefficient in thermodynamics. Its use would involve high pressure and special compressors. Currently, specialists in air conditioning and refrigeration are interested again by:
- Its low environmental impact (ODP = 0,GWP = 1);
- The low specific volume resulting in facilities with low volume (small leak);
- It has the distinction of having a low critical temperature at 31 °C at a pressure of 73.6 bars.[4]

II. LITERATURE REVIEW-

This investigation thermodynamically analyzes a vapor compression refrigeration system which compares R134a and R290/R600a refrigerants. The refrigerants like R12 and R22 contain chlorine atoms which are main reasons for the emission of Chlorofluorocarbon which is responsible for the ozone depletion. Hence, the alternate refrigerants like R-134a and hydrocarbon mixture (R290/R600a) are used to avoid emission of CFC. These refrigerants have zero ozone depletion potential and negligible global warming potential. The COP of the system was improved by replacing the R134a with blended Hydrocarbon R290/R600a refrigerant. In this paper, the experimental analysis of R134a and various ratios of R290/R600a refrigerants have been analyzed. In the present work performance comparison between R-134a and hydrocarbon mixture (R290/R600a) has been carried out in domestic refrigerator. Generally, the overall performance of the applied mixtures was much better than that of R134a [1]

In this paper 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.[2]

In this work, the performance of vapors compression refrigeration system with the following refrigerants has been investigated experimentally as a retrofit for R134a. 1. R600a/R1270(90/10by weight percentage) 2. R600a/R1270(80/20by weight percentage) The performance studies have been carried out with REFPROP database for property reference. The performance analysis raveled that the new refrigerant mixture performed better than that of R134a.It has been found that new refrigerant R600a/R1270(90/10by wt.%) and R600a/R1270(80/20by wt.%) blend has better performance that improved the COP of the system by5-12%and 9.7-15.6% higher than R134a.This is due to their higher refrigerating capacity than that of compressor power consumption. This mixture achieved lower freezer air temperature compared to R134a.The results of the present investigation have proved that the new alternative refrigerant R600a/R1270(90/10by wt.%) and R600a/R1270(80/20by wt.%) blend could be a better substitute for R134a[3]

In this paper exegetics approach is used to analysis the performance of theoretical vapors compression refrigeration cycle using R404A, R407C and R410A. The equations of energetic efficiency and exergy destruction for the main system components such as compressor, condenser expansion device, liquid-vapour heat exchanger and evaporator are developed. The relations for total exergy destruction in the system, the overall exegetics efficiency of the system and EDR related to exergetic efficiency are obtained. Also, an expression for COP of refrigeration cycle is developed. This investigations shows that results are obtained for the effects of evaporating temperatures, condensing temperature, degree of subcooling and effectiveness of liquid-vapour heat exchanger on COP, exergetic efficiency and EDR of theoretical refrigeration cycle. Commonly, simple vapour compression refrigeration systems are used for comfort cooling and cold storage application. Depending upon the applications evaporating temperature varies from –50 °C to 7 °C (Bilal and Syed, 2011). The scientists investigate more environmentally friendly refrigerants to resolve the problems of ODP and GWP. Currently, the following three refrigerants are being used as alternatives to CFC in various applications: R404A, R407C and R410A. Though, these three refrigerants are completely harmless to ozone layer, but sometimes they can add to global warming due to their leaks [4]

This paper presents a performance analysis of vapour compression refrigeration system with using refrigerants like R-134a & Blend of R-290(propane) (50%) and R-600a (50% Isobutane). Various performance measures like compressor discharge temperature, pressure ratio, volumetric cooling capacity (VCC), volumetric efficiency and mass flow rate are analyzed. The performance in term of coefficient of performance (COP), refrigerating capacity (RC), and compressor work (We) were evaluated for the investigated refrigerants at various evaporating and condensing temperatures. The system performance increases as the evaporating temperature increases, but reduces as the condensing temperature increases. The COP of R134a obtained was lower than those of Blend of R- 290(propane) (50%) and R-600a (50% isobutane). [5]

III. **PROBLEM STATEMENT**

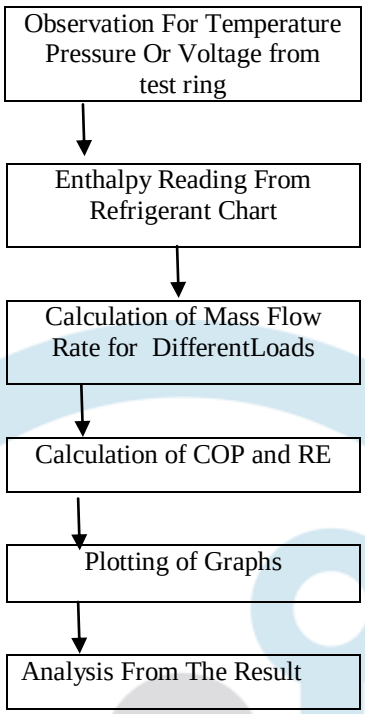
The use of CFC and HCFC refrigerants has led to the breakdown of stratospheric ozone molecules and global warming. A decrease in the ozone layer can significantly increase the incidence of skin cancer, eye damage, decreased crop yield and damage to forests and aquatic life. In addition, ozone depletion in the stratosphere can aggravate the photochemical pollution. On the other hand HFC refrigerants that would serve as potential replacements have a global warming effect. The green house warming effect causes an increase in global temperatures and associated catastrophic effects such as rising sea level, changes in the amount and pattern of precipitation, increasing the frequency and intensity of extreme weather events, fluctuations in agricultural yields as well as glacier retreat. These days green house warming has become one of the most important of global issue. So that Hydro-fluorocarbons (HFCS) are the leading replacement for CFC & HCFC Refrigerant.

IV. **METHODOLOGY**

Steps for Analysis

1. Take observation for temperature and pressurefrom test rig using , R-134a ,R404AandHydrocarbon Blend.
2. Take readings for suction temperature,Compressor, discharge temperature, condenser, discharge temperature and evaporator, Temperature.
3. Using refrigerant chart (p-h curve) for , R-134a,R404A and Hydrocarbon Blend obtain values ofenthalpies for different load.
4. Calculatemass flow rate for different loads for R-134a , R404A and Hydrocarbon Blend.
5. Calculation of Refrigerating effect and COP for different loads.
6. Plotting of graphs for:
a. COP Vs Power.
b. R.E. Vs Evaporator Temperature.
c. R.E. Vs Condenser Temperature.
d. Mass flow Rate Vs Evaporator Temperature.
e. Mass Flow Rate Vs Condenser Temperature.
7. Analysis from the result for performance comparison of refrigerants.

Flow Chart For Analysis



V. SCOPE FOR FUTURE WORK-

- To study the effect of new efficient, minimum GWP, minimum ODP and environmental friendly refrigerants.
- Innovation of new refrigerant mixture having high COP with less environmental impact.
- To develop a mathematical model by considering multiple factors so that experimental investigation can be minimized.

The review of the literature, R134a is the leading refrigerant in India which is used to substitute R12 due to its high ODP value. Even though R134a is non toxic, non-flammable and has a zero ODP. It also be seen that most of the available alternative refrigerants are not matching with the R134a in various aspects such as saturation properties, energy efficiency and safety. So that the Hydrocarbon blend has better energy efficiency but is inflammable issues, which restrict the usage in existing systems. So that they can be made less flammable by blending flammable refrigerant with non flammable refrigerant such as HC refrigerants with HFC refrigerants.

It is possible to mix hydrocarbon refrigerants with other alternatives such as HFC refrigerants. The miscibility of HFC/HC mixtures with POE oil has been reported to be good. The GWP of HFC/HC mixtures is less than one third of HFC, when it is used alone.

The proposed mixture is expected to work with the existing components of conventional R134a systems with an improvement in the system performance. This can solve the issues faced by refrigeration sector in the near future due to phase out of R12 and reduction of green house effect with the decrease of R134a quantity in the proposed mixture.

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