R32 the Future Refrigerant

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R32- THE FUTURE REFRIGERANT

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Abstract

In early 2010 the manufacturing and distribution of R22 refrigerant was banned. Due to its increasing effect on the environment with the production of CFC gases, depletion of ozone layer had lead to rise in global warming. R22 refrigerant which was used commonly in AC systems has had a major impact on air conditioning costs. Initially R134a and then R410a were replaced with R22 refrigerant in the industry due to the Montreal protocol. In this paper there is a detailed study done of R32 refrigerant along with its chemical and thermodynamic properties and its comparison with the refrigerants currently used in the refrigeration industry.

The ODP of R22 refrigerant was very high while that of other refrigerants such as R410a, R134a which are currently in use is comparatively very low. The ODP of R32 refrigerant is zero which makes it extremely environmental friendly as compared to all other refrigerants. The GWP of R22 refrigerant is very high while the GWP of R32 as a pure refrigerant is least when compared to all other refrigerants. Till these times, R410a refrigerant dominated the RAC industry due its less cost and ease of availability.

Keywords.Global Warming Potential, Chlorofluorocarbon, Chlorodifluoromethane

Introduction

With development of mechanical refrigeration's in early 1900s most commonly used refrigerants were NH_3, CO_2, SO_2, and NH_2Cl. These refrigerants were found to be either very toxic or hazardous. In 1931 a safer alternative was available with input of CFCs and HCFs which had many suitable properties such as stability, non toxicity, good thermodynamic properties, non flammable and good material compatibility. The results shown by the researchers concluded that existence of chlorine in stratosphere depleted the ozone layer. CFCs and HCFs with ozone. Chlorine atoms react with ozone which converts to oxygen. A series of International treaties had been formed to put an end to the halogenated fluids for stopping the depletion of ozone layer.

From past few years in vapor compression based refrigeration industries CFCs and HCFs have been extensively used due to their enhanced thermo physical and thermodynamic properties. Though, CFCs and HCFs have been extensively used due to their enhanced thermo physical and thermodynamic properties. Though, CFCs and HCFs contain ODP and high GWP they were ruled out in all the developing nations in 2010 and will be phased out by 2030 in all the developed nations with respect to the Montreal protocol. Hence, there is very high demand for development of newly eco friendly refrigerants.

Recent studies have suggested the green house gases emitted and which are depleting the ozone layer caused by human activities have invariably increased over last few decades. A prediction made by (Intergovernmental panel on climate change, 2014) have said that in a worst case scenario if no further actions are implemented by the government then the mean surface temperature of earth will rise by around to 4.8K by 2100.The usage of air conditioning systems residentially alone symbolizes 28% of global energy demand, particularly in warmer countries.

Apart from the consumption of electricity one of the other major contributions for climatic change is due to leakage of refrigerant gases in atmosphere from vapor compression cycles. There is usage of R410a as a working fluid which is chlorine free HFC mixture used in USA, Europe and well developed countries. The main drawback of R410a is its very global warming potential (1930 over 100 years). It is estimated that when compared to CO_2 it is 2000 times more dangerous. For achievement of steady drop of green house gases, conventionally used refrigerant R410a shall be completely substituted by lower GWP fluids keeping in mind the efficiency of vapor compression system.

Objectives

1. To compare various refrigerants based on their thermo physical and chemical properties.

2. To compute thermodynamic performance parameter of actual vapor compression system such as compressor work, refrigeration effect, COP, compressor discharge temperature and volumetric refrigeration capacity at condensing and evaporating temperature.

3. To select a refrigerant with lowest GWP.

4. To select a refrigerant with zero ODP.

5. To investigate theoretically and experimentally the behavior of different refrigerant fluid focusing primarily on R32 refrigerant.

6. To find the refrigerant with maximum efficiency optimum characteristic performance.

7. To evaluate the experimental and theoretical results and compare it in order to identify and conclude with the results obtained.

Methodology

The experiment used a test rig which was a complete VCRs developed forming a single temperature domestic refrigerator which was designed to work with R134a.

It has a capacity of 120 liters. It consists of an evaporator air cooled condenser which has a wired mesh and reciprocating compressor which is hermetically sealed. There are two pressure gauges one at the inlet other at the outlet of the compressor for measurement of suction and discharge pressure respectively.

The testing of the three refrigerants with sub-cooling heat exchanger included measurement of pressure, mass flow rate, power consumption and temperature. The obtained data was used for evaluation of performance characteristics of domestic refrigerator. Refrigeration capacity was calculated using the equation given below :

$$Q=m\,(h_1-h_4)$$

Where,
m=mass flow rate
h1=refrigerant enthalpy at evaporator outlet
h4=refrigerant enthalpy at evaporator inlet

The compressor work was calculated using the equation given below:

$$W=m\,(h_2-h_1)$$

Where,
m=mass flow rate
h2= refrigerant enthalpy at compressor outlet

$$COP=Q_{evap}/W$$

Where,
Qevap= refrigeration capacity
W=compressor work

60g of R134a was first charged and tested in various conditions. In RAC workshop test were carried out under normal atmosphere. Average ambient air temperature was recorded. Similarly 80g, 100g, 120g of R134a was recorded. The same experiment was recorded for R32 and R410a refrigerants.

ANALYSIS AND DISCUSSION

The analysis of all known and currently used as well as the outdated refrigerants was thoroughly made with many quality international journals and research papers and each refrigerant which are used currently were compared to the pure refrigerants of the upcoming generation. All the thermo-physical properties of each refrigerant were studied in detail and it was found that comparison of refrigerants such as R134a, R410a and R32 was to be made in the experiments which are to be performed in laboratories in the upcomingsemester.

Furthermore, all the points were taken into consideration while implementing the plan to make it successful after experimentation. The heat transfer and pressure drop results obtained after research work were much better for R32 than any other refrigerant and this refrigerant must be used as an alternative to other refrigerants in RAC industry. Zero ODP of the refrigerant was given utmost preference as it does not affect the ozone layer in any way and low GWP was also seen of these refrigerants as compared to the others

Refrigerant Name	ODP	GWP (100 years)	Molecular Mass	Critical Temp(deg C)	Critical pressure (kPa)
R11	1	4750	137.4	197.96	4408
R12	0.820	10680	120.9	111.97	4136
R22	0.055	1810	86.5	96.14	4990
R134a	0	1430	102	101.06	4059
R410a	0	2088	72.6	70.17	4770
R32	0	675	52	78.11	5782

LITERATURE REVIEW

GWP of R32 refrigerant is almost more than three times less when compared to R410a and two times less when compared to that of R134a.Also, we can see that the critical temperature of R32 refrigerant is more than R410a hence higher COP can be obtained and efficiency increased. In terms of the thermo-physical properties we can decide if a R32 refrigerant is a better refrigerant than R134a and R410a.

In order to determine one of the better refrigerants keeping in mind the ease of availability and cost effectiveness the survey from various foreign research papers was done and data was collected for individual refrigerants and the experimental results were recorded in order for research work and further implementation to be done with the experiments in laboratory.

R134a Refrigerant

R134a refrigerant also known as tetrofluoroethane (CH_3CH_2F), is another very important refrigerant in RAC industry commonly used in household appliances, centrifugal chillers and automotive Air conditioners. It is highly efficient in performance and has been in industry since last 20 years. It has been used as a replacement instead of R12 refrigerant rotary scroll, reciprocating compressors and centrifugal areas. It is a very safe refrigerant for normal handling purposes and is non-toxic, non-flammable and non-corrosive

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R32 Refrigerant

R32 refrigerant also called as difluoromethane is similar to the performance characteristics of R410a and is expected to have a better COP when used in RAC industry due to its slightly higher critical temperature. The best thing about R32 refrigerant among other refrigerants is its least GWP and zero ODP.
R32 has been rated an A2L refrigerant under ISO817, it signifies that it has a very wide range of potential uses due to low flammability and low toxicity.
It can be easily reused and recycled and even if leakages occur, there are no composition changes.
According to research study done by NIT Surathkal, the analysis showed a higher side of COP up to 15.92% for R32 and 11.71% for R134a among the comparison of six other previously used refrigerants namely R22, R152a, R290,R600a, R1234yf and R513a. The theoretical thermodynamic properties of various refrigerants were done in standard VCS.

Benefits of using R32 refrigerant

- It has zero ODP.
- The GWP of R32 is One third of that of R-410a.
- It requires less charge due to 22% higher volumetric capacity.
- Development is easier due to similar saturated pressure.
- COP when compared to R410a is high since higher critical temperature.
- The quantity of charge needed is smaller due to lower density.
- It is easier to be produced and managed, since it is a single component of gas.
- The heat needed to evaporate R32 is greater so the required mass flow rate per unit cooling capacity is smaller and the COP is higher.
- R32 refrigerant has got a higher volumetric cooling effect capacity when compared to R410a, allowing us to reduce the pipe size and increase the efficiency of the system.
- R32 is less flammable than hydrocarbons.

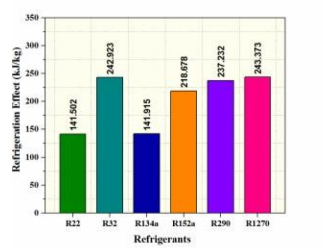
R22 Refrigerant

R22 refrigerant which is also call Freon is an HCFC. It was earlier used worldwide for air conditioning systems. With extremely high ODP and GWP of R22 refrigerant it was banned in 2010 worldwide due to harmful effect on ozone layer and environment. Soon after the Montreal protocol this refrigerant was stopped being used.This refrigerant is a 50% mixture of R32 and 50% mixture of R125 refrigerant. It is used in air conditioning equipments and heat pumps.

R410a Refrigerant

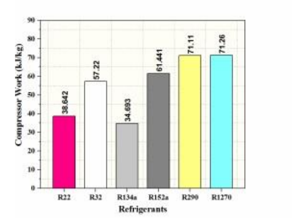
This refrigerant is a 50% mixture of R32 and 50% mixture of R125 refrigerant. It is used in air conditioning equipments and heat pumps.
Currently, R410a refrigerant is the most common in use in well developed countries. R410a when compared with R22 refrigerant has higher volumetric cooling capacity and better thermal exchange properties. If all R410a were converted to R32, the impact to global warming from HFCs in 2030 will be reduced by the CO_2 equivalent of approx. 800 million tons (20%) compared to the current use of R410A.

Thermodynamic Performance parameters of pure refrigerants



Refrigeration effect

The following figure shows the achieved cooling effect of six refrigerants and it is observed that the R32 is moderately high when compared to R22 and R134a. This is due to the high latent heat of vaporization when compared to R22.



Compressor Work

The compressor work of R290 and R1270 was observed to be higher when compared to R22 refrigerant due to high vapor enthalpies of these refrigerants. While the compressor work of R32 refrigerant was found to be moderate

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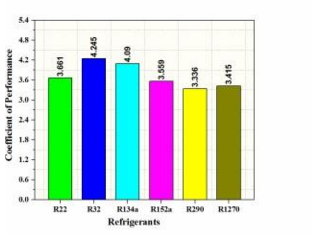
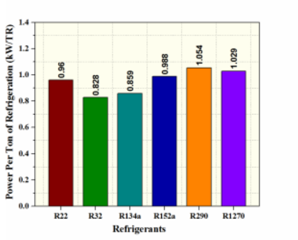
Coefficient of Performance

The COP of R32 and R134a is clearly higher than R22 by 15.95% and 11.71% respectively as shown in the figure below.



power per ton of refrigeration

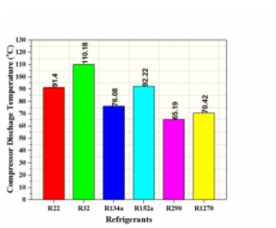
This represents the electrical work input requires for the compressor to produce per ton of refrigeration. It is estimated and found out that R32 refrigerant consumes 13.75% lower energy when compared to six different refrigerants due to the type of refrigerant and device operation method.



Volumetric Cooling Capacity

The two factors onto which the volumetric cooling capacity depends on is the refrigeration effect and density of refrigerant vapor. It signifies the cooling capacity per unit volume at evaporator outlet. From the figure we can evidently say that R32refrigerant has a very high volumetric cooling capacity

Compressor discharge temperature



This is done to ensure the lifetime and steadiness of compressor. It has been taken into account that the compressor discharge temperature for R1270 and R290 was lower than R22 by 20 to 26 degrees centigrade. Due to high discharge temperature of R32 refrigerant it is not recommended to be used for high temperatures in industry.

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CONCLUSION

From the experimental setup we have compared R410a, R134a with R32 refrigerant which has zero ozone depletion potential and low global warming potential. At the end of the experiment conclusion can be drawn that:

1) Refrigerating effect of R32 is high due to viscosity as compared to other two refrigerants.
2) Coefficient of performance of R32 is more in ambient temperature because of high compressor work than R410a.
3) Coefficient of performance depends on the refrigerating effect i.e. COP of R32 is more due to high refrigerating effect.
4) Working with different ambient temperatures decreases the work input by the compressor when compared with the refrigerants.
5) When heating effect was taken into consideration with the increasing ambient temperature there is slightly decrease in efficiency .Although R32 provide more compressor work they have higher reduction heating effect as compared to R410a because of different working temperatures.
6) The only disadvantage of R32 is they have high discharge temperature which decreases the efficiency and life of the compression.
7) R410a,R134a discharge temperature is low due to Lowe adiabatic index of refrigerants.
8)R32 has better volumetric refrigeration capacity as compared to R134a,R410a
R32 requires smaller size compressor which makes the product cost efficient
R410a and R134a need large space for compressor because of low volumetric refrigeration capacity.

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