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RESEARCH ARTICLE

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PERFORMANCE COMPARISON ON VAPOUR COMPRESSION REFRIGERATION SYSTEM BY USING ALTERNATE REFRIGERANTS

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ABSTRACT

Refrigerant, Global warming In this project work, a performance comparison of vapour compression refrigeration system using alternate refrigerant will be carried out and their results will be compared with Tetrafluoroethane (R134a). The alternate refrigerants will be blended from two different blends one as R134a (10%), R32 (10%) and R152a (80%) and the other as R32 (10%), R600a (10%) and R152a (80%). The result will be expected that alternative refrigerants R134a, R32 and R152a have a slightly higher COP than R134a at various evaporating temperature. Also in this work global warming potential (GWP) will be studied, because global warming potential (GWP) have become the most important criteria in the development of new alternate refrigerant. The effect of main parameter on performance analysis such as degree of super heating, degree of sub cooling, and volumetric refrigeration capacity will also be investigated for various operating temperature using alternate refrigerant. Potential, Evaporating Temperature etc.

I. INTRODUCTION

Refrigeration and air-conditioning system plays an important role in modern life. They not only provide comfortable and healthy living environments, but have also come to be regarded as necessities for surviving severe weather and preserving food. Unfortunately, accelerated technical development and economic growth throughout the world during the last century have produced severed environmental problems, forcing us to acknowledge that though these technological advances may contribute to human comfort, they also can threaten the environment through ozone depletion (ODP) and global warming Potential (GWP).

The linkage of the CFC refrigerants to the destruction of the ozone layer, which has been established recently, is attributable to their exceptional stability because of which they can survive in the atmosphere for decades, ultimately diffusing to the rarefied heights where the stratospheric ozone layer resides. The inventors of these refrigerants could not have visualized the ravaging effects of the refrigerants on the ozone layer. This paper analyses the processes of selecting environment friendly halocarbon refrigerants that have zero ODP, non-flammable, non-toxic and low GWP. It also examines and discusses the current available alternative refrigerants in vapour compression refrigeration system.

II. FLUID SELECTION

In refrigeration and air conditioning systems selection of an appropriate working fluid is one of the most significant steps for a particular application. Zero ozone depletion potential (ODP) and Low global warming potential (GWP) has been inserted to the long list of desirable criteria of refrigerant's selection. In fact, environmental characteristics of refrigerants are becoming the dominant criteria provided that their thermodynamic behaviors and safeties are favorable as well. The selected refrigerants are as follows.

- Tetrafluoroethane (R134a)
- Difluoroethane(R152a)
- Iso butane (R600a)
- Difluoromethane (R32)

A. *Tetrafluoroethane (R134a)*

R134a is a haloalkane refrigerant with thermodynamic properties similar to R-12 (dichlorodifluoromethane) but with less ozone depletion potential. It has the formula CH_2FCF_3 and a boiling point of −26.3 °C at atmospheric pressure. R-134a cylinders are colored light blue.

R-134a was the first non-ozone-depleting fluorocarbon refrigerant to be commercialized. It was developed more than 20 years ago to have characteristics similar to R-12. R-134a has been generally accepted by the automotive air conditioning industry, because of its low hose permeability and high critical temperature. Domestic refrigerator producers also find R-134a to be a viable refrigerant for their products.

R-134a has the benefit of being a single-component refrigerant and, therefore, does not have any glide. The disadvantage of R-134a lies in its relatively low capacity, compared to R-22. R134a is an inert gas used primarily as a "high-temperature" refrigerant for domestic refrigeration and automobile air conditioners.

B. *Difluoroethane(R152a)*

R152a is a pure HFC refrigerant with a GWP of about 130, it is slightly inflammable and is classed A2. Operating pressure is almost equal to R134a and COP is higher. It has recently been approved for use in automobile applications as an alternative to R-134a.

R-152a is the only HFC refrigerant that still can be considered as an alternative for R-134a in air conditioning systems. Its chemical properties are like those for R-134a, thus it could be used in existing production system with just some small changes.

R152a has 10% of GWP for R-134a with smaller refrigerant charge than R134a, in the other words at systems with R-152a as working fluid; refrigerant charge is about 35% lower than that for R-134a. Due to its larger molecules in comparison with R-134a, R152a has less refrigerant leakage. It has been proposed as a "drop-in "replacement for R-134a.

R-152a is mildly flammable. One way to decrease the flammability risk is to reduce the refrigerant charge in the system. Hence R152a can be detained in a compact refrigeration system in order to decrease its risk to ignite. Also using a compact heat exchanger with mini/micro channels reduces internal system volume and therefore the charge inside the refrigeration system can be reduced.

C. Iso butane (R600a)

Isobutane (i-butane), also known as methylpropane, is an isomer of butane. It is the simplest alkane with a tertiary carbon. Concerns with depletion of the ozone layer by Freon gases have led to increased use of isobutane as a gas for refrigeration systems, especially in domestic refrigerators and freezers, and as a propellant in aerosol sprays. When used as a refrigerant or a propellant, isobutane is also known as R-600a. Some portable camp stoves use a mixture of isobutane with propane, usually 80:20. Isobutane is used as a feedstock in the petrochemical industry, for example in the synthesis of isooctane.

Isobutane is used as a refrigerant. The use in refrigerators started in 1993 when Greenpeace presented the Green freeze project with the German company Foron. In this regard, blends of pure, dry "isobutane" (R-600a) (that is, isobutane mixtures) have negligible ozone depletion potential and very low Global Warming Potential (having a value of 3.3 times the GWP of carbon dioxide) and can serve as a functional replacement for R-12, R-22, R-134a, and other chlorofluorocarbon or hydro fluorocarbon refrigerants in conventional stationary refrigeration and air Conditioning systems.

D. ***Difluoromethane (R32)***

It has been investigating HFC-32 which has a GWP of 675 (68% reduction over R410A) due mainly to its cost being lower than R410A. HFC-32 is not a new refrigerant - it was studied during the 1990s in the search for a zero-ODP solution but was not adopted due to concerns about its flammability characteristics. But now, the requirement for Low-GWP likely requires accepting some flammability constraints for the refrigerants. HFC-32 and HFOs are both expected to be mildly flammable with an ASHRAE A2L flammability safety rating and involve significant tradeoffs among efficiency, GWP, and cost. The Air Conditioning, Heating and Refrigeration Institute (AHRI) has launched since July 2011 a global Low-GWP Alternative Refrigerants Evaluation Program (LGWP AREP) to pool industry resources for system and compressor test evaluations involving over forty LGWP candidates for various applications.

Although regulation efforts are focused on the GWP metric due to the simplicity of relating to the direct emission impact of the refrigerant, it is actually more important to recognize the indirect emission from the efficiency impact of the refrigerant which can be more overwhelming than its direct emission, particularly for applications such as stationary A/C where the direct emission is typically no more than 5% of the total emission.

III. EXPERIMENTAL SETUP AND SPECIFICATION

Figure 1: Vapour compression refrigeration system

Table 1: Vapour compression refrigeration system specification

S.No	Components	Specification
1.	Compressor	Hermetically Sealed, Capacity ¼ Ton, 230 V AC.
2.	Condenser	Finned Copper Tube Condenser with condenser fan & motor
3.	Evaporator	Coiled Evaporator immersed in Water
4.	Expansion Device	Capillary Tube
5.	Flow meter	Glass Tube Rotameter for Refrigerant Flow
6.	Pressure gauge	0 to 300 PSI
7.	Compound gauge	-30 to 150 PSI
8.	Water Circulating Pump	Centrifugal pump
9.	Electric Heater	Capacity 1 kW, Supply 230 V AC
10.	Dimmer	Range 0-250 V AC, 4 A
11.	Digital Voltmeter	Range 0-500 V AC
12.	Digital Ammeter	Range 0-5 A AC
13.	Temperature Sensors	5 Nos.

IV. ANALYSIS OF REFRIGERENT

In general refrigerants should have the following thermal properties for better performance and obtain maximum efficiency.

- Low vapour pressure for reducing compressor work
- Moderate liquid density
- Low vapour density in gaseous form
- High latent heat at low temperature increase the refrigeration effect.

By using REF PROP software we obtained the above mention properties at various evaporating temperature for selected alternate refrigerant.

A. ***Properties of individual Refrigerants***

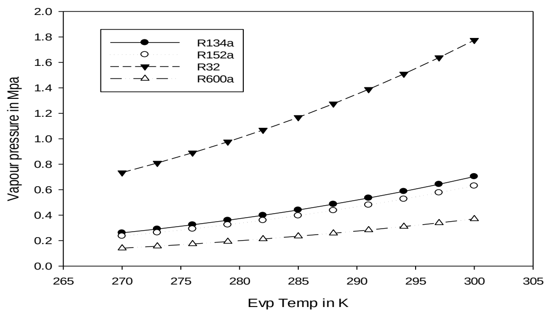

Figure 2: Effect of evaporator temperature on vapour pressure

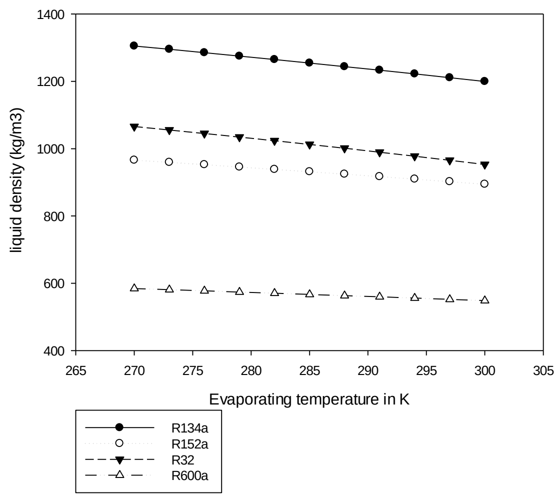

Figure 3: Effect of evaporator temperature on liquid density

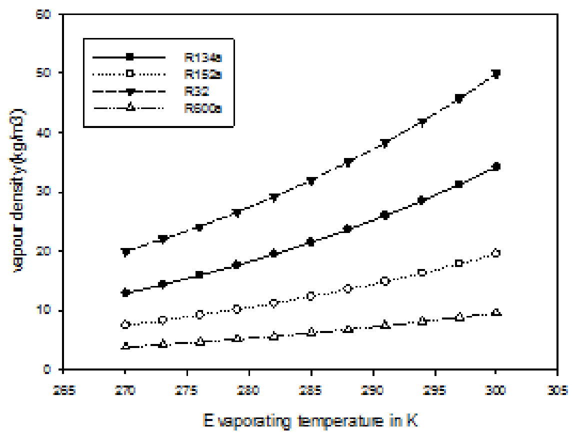

Figure 4: Effect of evaporator temperature on vapour density

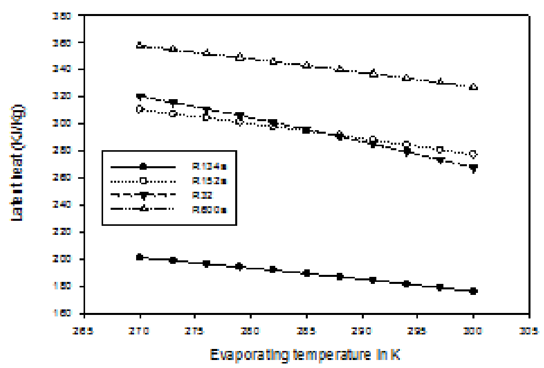

Figure 5: Effect of evaporator temperature on latent heat

B. *Properties of blended refrigerants*

Here we found out the property of blended refrigerants and compare the blended refrigerant with R134a. First combination of blended refrigerant such as R152a (80%), R134a (10%) and R32(10%), and the second combination are R152a (80%), R600a (10%) and R32(10%), in mass basis by using REF PROP software.

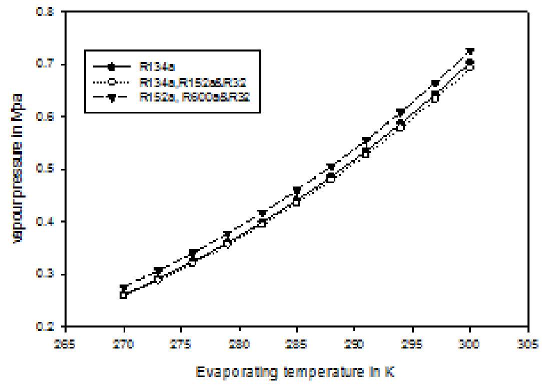

Figure 6: Effect of evaporator temperature on vapour pressure

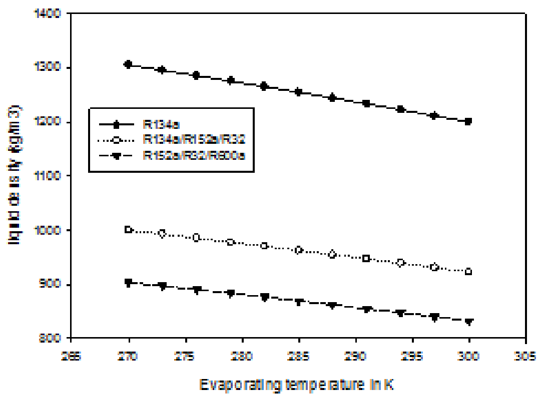

Figure 7: Effect of evaporator temperature on liquid density

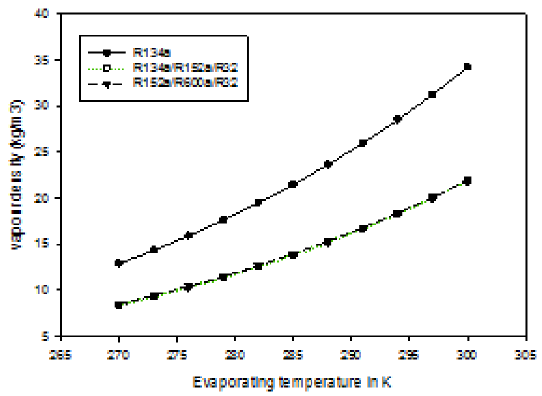

Figure 8: Effect of evaporator temperature on vapour density

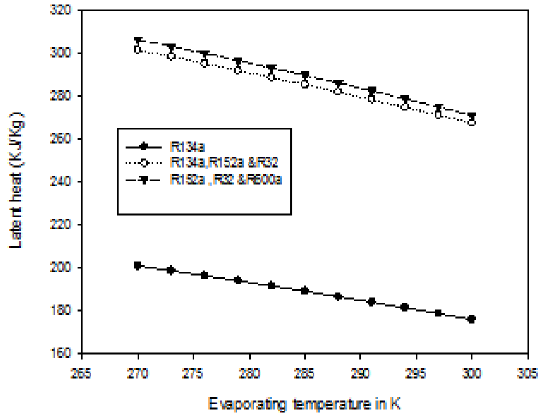

Figure 9: Effect of evaporator temperature on latent heat

From the above graph shows that the first combination blended refrigerant have satisfy the desired parameter, when compared to R134a and the second blended combination. So we are going to analyze the blended refrigerant for study the actual performance and finally compare with R134a.

V. RESULT AND DISCUSSION

To obtain the actual performance of blended refrigerant, we go for experimental analysis by using vapour compression test apparatus. For ensure a accurate COP(coefficient of performance) take variation of temperature with short interval of time period and the result are discussed below.

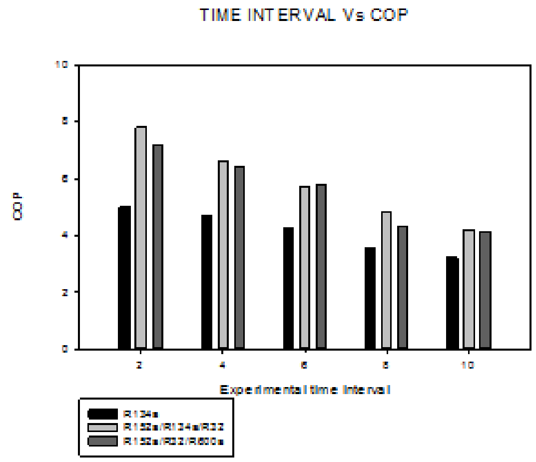

Figure 10: Effect of Exp time interval Vs COP

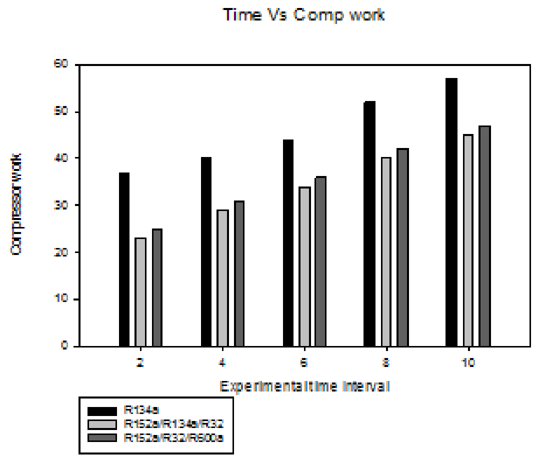

Figure 11: Effect of Exp Time Vs Comp Work

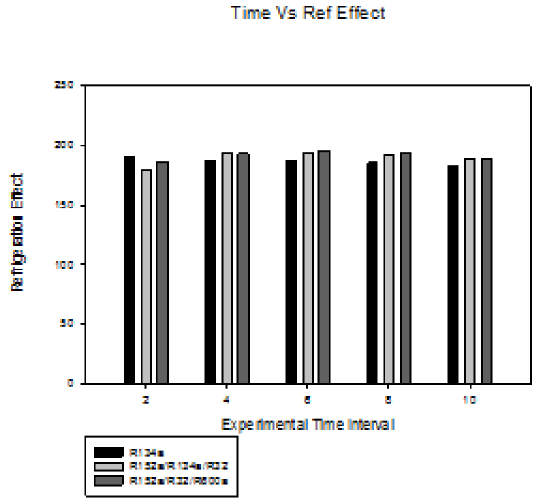

Figure 12: Effect of Exp Time Vs Refrigeration effect

After conducting the experimental analysis graph to be drawn for Coefficient of performance, Refrigeration effect and compressor work. The above graph shows that Blended refrigerant have better performance and Increase COP of the system also reduce the compressor work.

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