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Exploratory Study of Thermodynamics Performance of R 134a, R 152a and R 1234yf in Vapour Compression Refrigeration cycle

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Abstract
The Study present in this article focuses on the research of alternate eco friendly refrigerants with remarkable coefficient of performance and reduced global warning potential and zero ozone depletion potential. Objective of this experimental investigation is to study the performance of R134a and R152a and R1234 yf refrigerant in vapor compression cycle and their comparison with various parameter. The result showed the alternative refrigerant R1234 yf investigated in the analysis have higher coefficient of performance than R152 a and lower than R134a. This experimental investigation is conducted on vapor compression refrigeration Test Rig in applied thermodynamic lab of Khalsa College of Engg. and Technology.

1. Introduction

Climate change is a paramount issue in modern day world. Many factor are responsible for this and one of the major factor which is liable for global warming is refrigeration which we are using in daily life appliances. These refrigerant are just adding fuel to the fire.As we know every refrigerant has some pros and cons. So we have to think twice before using them. The problem of climate change is increasing by leaps and bound on the contrary we are researching at snails pace [1-3].

1.1 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 compressors. It is safe for normal handling as it is non-toxic, non-flammable and non-corrosive.Currently it is also being widely used in the air conditioning system in newer automotive vehicles. The manufacturing industry use it in plastic foam blowing. Pharmaceuticals industry use it as a propellant.It exists in gas form when expose to the environment as the boiling temperature is -14.9°F or -26,1°C.This refrigerant is not 100% compatible with the lubricants and mineral-based refrigerant currently used in R-12. Design changes to the condenser and evaporator need to be done to use this refrigerant. The use of smaller hoses and 30% increase in control pressure regulations also have to be done to the system [4].

1.2 R152a

1,1-Difluoroethane, or DFE, is an organofluorine compound with the chemical formula C2H4F2. This colorless gas is used as a refrigerant, where it is often listed as R-152a (refrigerant-152a) HFC-152a (hydrofluorocarbon-152a). It is also used as a propellant for aerosol sprays and in gas duster products. As an alternative to chlorofluorocarbons, it has an ozone depletion potential of zero, a lower global warming potential (124) and a shorter atmospheric lifetime (1.4 years). It has recently been approved for use in automobile applications as an alternative to R-134a.

In addition to serving as a refrigerant, 1,1-difluoroethane is also commonly used in gas duster (commonly thought of a: "canned air") and many consumer aerosol products, especially those subject to stringent VOC requirements.The molecular weight of di fluoroethan: is 66, making it a useful and convenient tool for detecting vacuum leaks in CC-MS systems due to high availability the gas can be sprayed around common sources of leaks while manually observing the mass spectrum scan around mz 66 and looking for a peak to detect the source of the leak [5].

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1.3 R 1234 yf

2,3,3,3-Tetrafluoropropene, or 1-F0-1234yf is a hydrofluorolefin (FIFO) with the formula CH-2=CFCF3. This calories& gas has been proposed as a replacement for R-134a as a refrigerant in automobile air c3nditioners.HFO-1234yf is the first in a new class of refrigerants acquiring a global warming potential (GWP) rating 1/335 that of R-134a and only 4 times higher than carbon dioxide.HF0-1234yf, which has a 100-year GWP lower than 1, could be used as a "near drop-in replacement" for R-134a, the cuf.•ent product used in automobile AC systems, which has a 100-year GWP of 1430. This means that automakers would not have to make significant modifications in assembly or in vehicle system designs to accommodate the product.Although the product is classified slightly flammable by ASHRAE, several years of testing by SAE proved that the product could not be ignited under conditions normally experienced by a vehicle. In addition several independent authorities evaluated the safety of the product in vehicles and some of them concluded that it was as safe to use as R-134a [6].

1.4 Objectives

- To Determining the Coefficient of Performance (COP) of R152a , R134a and R1234yf .
- Comparsion of Coefficient of Performance and other parameter such as temperature (T_1) of refrigerant before entering to compressor, temperature (T_3) of refrigerant after condenser, temperature (T_2) of refrigerant after exiting from compressor ,temperature (T_4) of refrigerant after expansion valve with time is made.

Fig.1: Photographic View of Experimental Set Up

2. Experimental Setup Vapor Compression Refrigeration System (VCRS)

A Vapor Compression Refrigeration System is an improved type of Air Refrigeration System in which a suitable working substance, termed as Refrigerant is used. It Condenses and evaporates at temperatures and Pressures close to the atmospheric Conditions.

The Refrigerant used does not leave the System but is circulated throughout the system alternately condensing and evaporating. The Vapour Compression Refrigeration system as shown in figure1 and 2 is used now days used for all-purpose refrigeration. It is used for all industrial purpose from a small domestic refrigerator to a big air-conditioning plant [7].

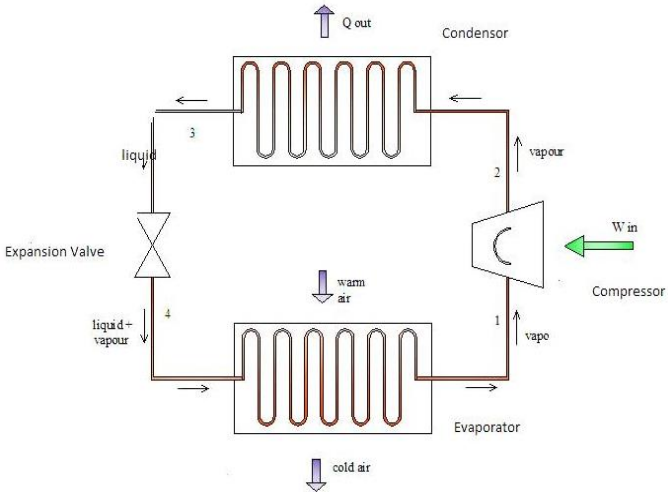

Fig.2: Schematic view of vapor refrigeration cycle

3. Analysis

The vapor compressor cycle can be represented P-h diagrams as shown in Figure 3 when the liquid coming out of condenser is saturated liquid and vapor coming out of evaporator is saturated vapor.

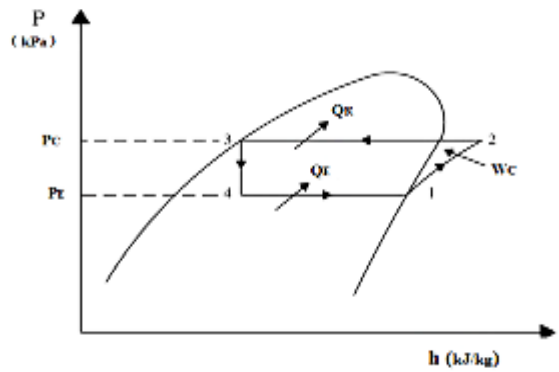

Fig. 3: P-H Diagram

- Process 1-2: Isentropic compression in the compressor.
- Process 2-3: Heat rejection in the condenser at constant pressure.
- Process 3-4: An irreversible adiabatic expansion of vapor through the expansion value. The pressure and temperature of the liquid are reduced. The process is accompanied by partial evaporation of some liquid.
- Process 4-1 Heat absorption in evaporator at constant pressure. The final state depends on the quantity of heat absorbed [8].

$$\text{COP} = \frac{\text{Heat extracted at low tempreature}}{\text{Work supplied}}$$

Heat extracted at low temperature = Heat transfer during the process 4-1 =Refrigerating effect.

$Q_2 = (h1-h4)$

Where h1= enthalpy at point 1

h_2= enthalpy at point 2

h_3= enthalpy at point 3

h_a= enthalpy at point 4

Theoretical compressor work (w) = (h_2- h_1)

$$\text{COP} = \frac{h1-h4}{h2-h1}$$

4. Result and discussions

Experimental performance comparison of R134a,R152a and R1234yf was done on the VCRS system for same cooling loads.

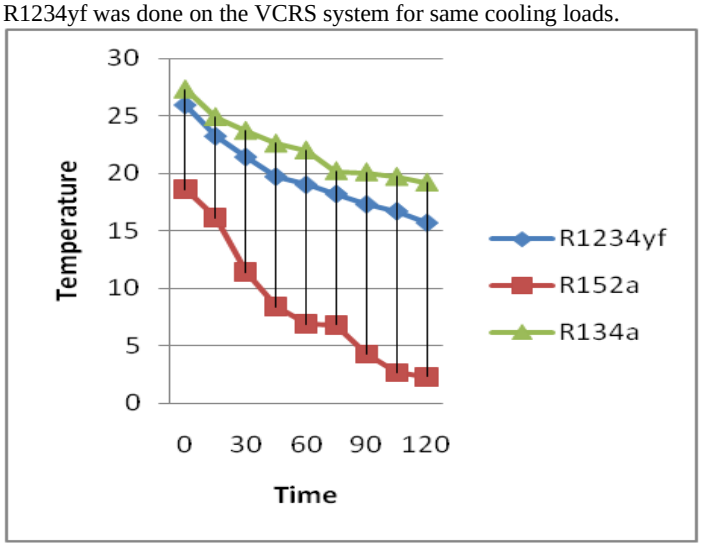

Fig.4: Comparison of temperature (t_1) before entering to compressor with time

Figure 4 shows variation of temperature (T_1) before entering to compressor with time at nine interval of 15 min each. There is reduction in temperature T1 with increase in time. R152 a has minimum evaporator temperature.

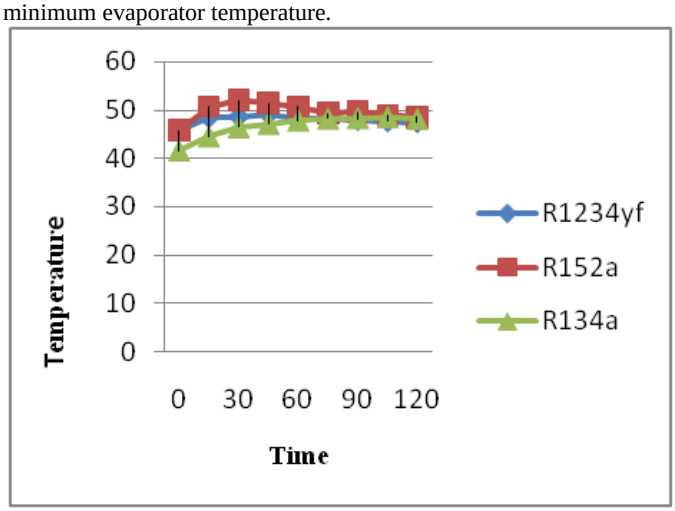

Fig.5:Comparison of temperature (t_2) after exiting from compressor with time

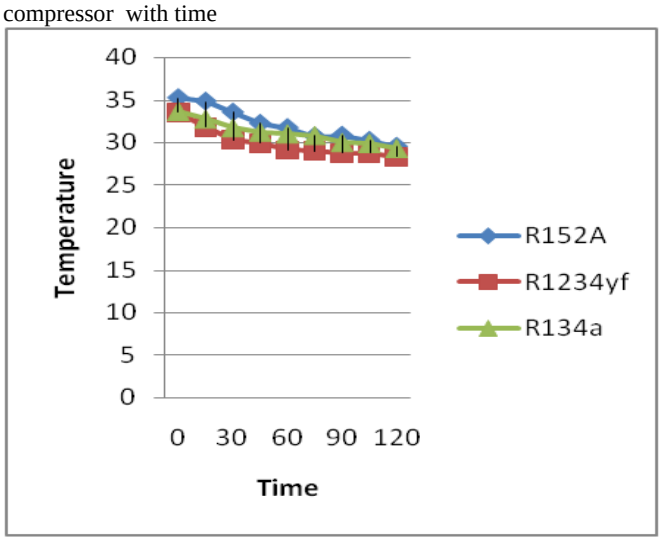

Fig.6: Comparison of temperature (t_3) after condenser with time.

There is slight variation between temperature of R-152a, R-134a, R1324yf while R152a shows highest temperature among three as shown in figure 5. There is reduction in temperature T3 with increase in time. The variation of temperature T3 does not vary significantly.

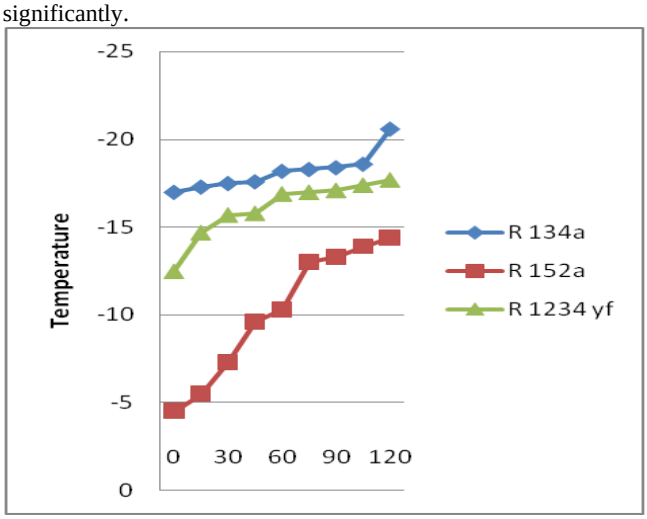

Fig.7: Comparison of temperature (t_4) after expansion valve with time

Above Figure show variation of temperature (T_4) after after expansion valve with time. Temperature of all three gases R-152a, R-134a, R1324yf are decreasing with the passage of time. Refrigerant R-134 a has minimum evaporator temperature among three.

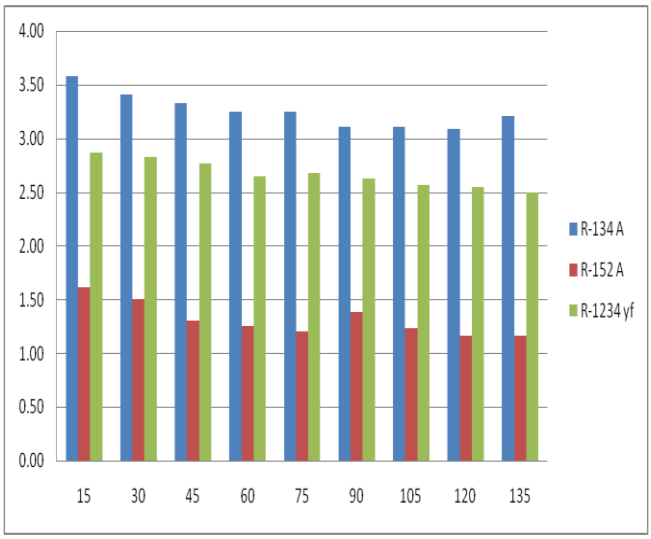

Fig. 8: Comparison of coefficient of performance with time

In the graph the overall comparison shows that the COP of R-152a is lowest whereas the COP of R-1234yf is higher than that of R-152a but lowest than R134a..

7. Conclusions

An experiment was performed in vapor compression refrigeration system with three different gases R-152a, R-134a, R1324yf and there coefficient of performance (COP) is calculated.The parameter such as T_1,T_2,T_3,T_4, refrigerating effect,workdone,Cop are studied at constant load. Based on experimental investigation of above three used refrigerant conclusion can be drawn:-

1. From figure8 it is clearly dipict that coefficient of performance of 134 is much higher than other two refrigerant at every interval of time.
2. The COP of R1234yf is in between R-134a, and R152a, however the Global Warming Potential of R1234 yf is lowsest among three gases used in experiment,making it eligible candidate for VCRS.

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