International Journal of Core Engineering & Management (ISSN: 2348-9510)
Special Issue, NCETME -2017, St. Johns College of Engineering and Technology, Yemmiganur

PERFORMANCE ANALYSIS OF R-508A AN ECO-FRIENDLY REFRIGERANT COMPARING WITH R-134A IN VCR SYSTEM

G.MD.JAVEED BASHA[1], S PRAKASH[2], Y MANOJ [3], A GNANENDRA REDDY [4]
[1]Asst.Professor,ME Dept., St.Johns College of Engineering and Technology, JNTUA,A.P, India.md.javeed.g@gmail.com
[2,3,4]Mechanical Engineering, St.Johns College of Engineering and Technology, JNTUA, India

---

Abstract

The aim of this project is to comparatively analyze of COP using R-134A & R-508A Refrigerant in Domestic refrigerator at steady state condition.Two different refrigerants are R-134A and R-508A. The refrigerant R-134A is zero ozone depletion layer and high global warning and R-508A is zero ozone depletion layer and low global warning.

The properties of R-134A and R-508A were taken from REFPROP data base. The condensing pressures varied between 1190kPa and 1950kPa, the evaporating pressures varied between 110kPa and 550kPa, and the sub-cooling temperatures varied between -55ºC and -75°C.

In the present research study a refrigerant property dependent thermodynamic model of a simple reciprocating system, which can simulate the performance of actual system as closely as possible, has been used to compare the characteristics of various refrigerants [R22, R134a, R410A, R407C and M20] used by world manufacturers to meet the challenges of higher efficiency and environmental responsibility while keeping their system affordable. Considering the recent trends of replacement of ozone depleting refrigerants and improvement in system efficiency, in the present study, R-508A can be a potential HFC refrigerant replacement for new and existing systems.

The effects of the investigated refrigerant on the depletion of the ozone layer increase in global warming, and flammable and toxic characteristics were considered. The usage of the refrigerant R-508A was found to be the best in terms of the coefficients of performance (COP), refrigerant charge rates and zero Ozone Depleting Potential (ODP).

I. INTRODUCTION:

In the past decades, the Ozone Depletion Potential (ODP) and Global Warming Potential (GWP) have becomes the dominant environmental issues, caused by the leakages of the CFC and HCFC refrigerants. The Montreal protocol (UNEP, 1997) declared the phasing out of CFC's and HCFC's as refrigerants that deplete the ozone layer (ODP) (UNEP, 1997). The Kyoto protocol (UNFCC, 2011) encouraged promotion of rules for sustainable development and reduction of Global Warming Potential (GWP) including the regulations of HCFC's (United Nations, 2011). Both of CFC and HCFC have high ODP and GWP.

International Journal of Core Engineering & Management (ISSN: 2348-9510)
Special Issue, NCETME -2017, St. Johns College of Engineering and Technology, Yemmiganur

1.1 DEFINITION OF REFRIGERATION:
The process of keeping an item below room temperature by storing the item in a system or substance designed to cool or freeze. The most common form of refrigeration is provided by systems (i.e. refrigerators) that use a refrigerant chemical to remove heat from items stored inside the system. The job of a refrigeration plant is to cool articles or substances down to, and maintain them at a temperature lower than the ambient temperature. Refrigeration can be defined as a process that removes heat. The oldest and most well-known among refrigerants are ice, water, and air. In the beginning, the sole purpose was to conserve food.

1.2 IMPORTANCE OF REFRIGERATION:
The first mechanical refrigerators for the production of ice appeared around the year 1860. In 1880 the first ammonia compressors and insulated cold stores were put into use in the USA. Electricity began to play a part at the beginning of this century and mechanical refrigeration plants became common in some fields: e.g. breweries, slaughter-houses, fishery, ice production, for example. After the Second World War the development of small hermetic refrigeration compressors evolved and refrigerators and freezers began to take their place in the home. Today, these appliances are regarded as normal household necessities.
There are countless applications for refrigeration plants now. Examples are:

1) Foodstuff conservation
2) Process refrigeration
3) Air conditioning plants
4) Drying plants
5) Fresh water installations

In fact, it is difficult to imagine life without air conditioning, refrigeration and freezing – their impact on our existence is much greater than most people imagine.

1.3 Azeotropic Blends:

- R-508A R-23/116 (39%/61%)
- R-116 hexafluoroethane
- R-23 trifluoromethane
- R-134a 1,1,1,2-tetrafluoroethane

II. REF-PROP SOFTWARE

2.1 INSTALLATION:

2.1.1 System Requirements
REFPROP is designed to run on any personal computer running the Microsoft® Windows® 98, 2000, XP, Vista, or similar operating system. The program requires 20 MB of hard disk space.

2.1.2 Installation
Place the REFPROP CD-ROM in the CD drive. Click [START], select [RUN] type in: D:\NIST2309, or whichever driver letter is associated with your CD reader. Follow the remainder of the

International Journal of Core Engineering & Management (ISSN: 2348-9510)
Special Issue, NCETME -2017, St. Johns College of Engineering and Technology, Yemmiganur

installation instructions. By default, REFPROP is installed in the C:\Program Files\REFPROP directory, but this can be changed by the user at installation. The user is cautioned to not change the names of the various files and subdirectories that are installed.

2.2 OVERVIEW:

This section presents a brief overview of the program and its main features. Please refer to the remaining sections for more complete information.

2.2.1 Database Structure

REFPROP consists of a graphical user interface (GUI) and FORTRAN subroutines implementing a variety of fluid property models. The interface provides a convenient means to calculate and display thermodynamic and transport properties of pure fluids and mixtures. The property models are written in FORTRAN and accessed by the GUI through a dynamic link library (DLL). The property subroutines can also be used by other applications, such as spreadsheets, independently of the GUI. The high-level subroutines that carry out iterative saturation and flash calculations are independent of the fluid property models. Underlying these subroutines are sets of core routines for each of the models implemented in the program. The numerical coefficients to the property models for each fluid are stored in separate text files. The coefficients for the mixture departure functions are stored in a single text file. Additional files contain information specifying predefined or user-defined mixtures. This structure simplifies the addition of new fluids and additional models to future versions of the database and makes such additions almost totally transparent to the user.

2.2.2 Use of the Database

Start the REFPROP program by double-clicking on its icon. A banner screen displays the title, credits, and a legal disclaimer. Clicking the "Information" button calls up further details and credits through the help system. Clicking the "Continue" button starts the program. The program is controlled, in the usual fashion of a Windows application, by the use of pull-down menus displayed across the top of the application window.

III. DISCUSSION OF THE REF-PROP DATABASE

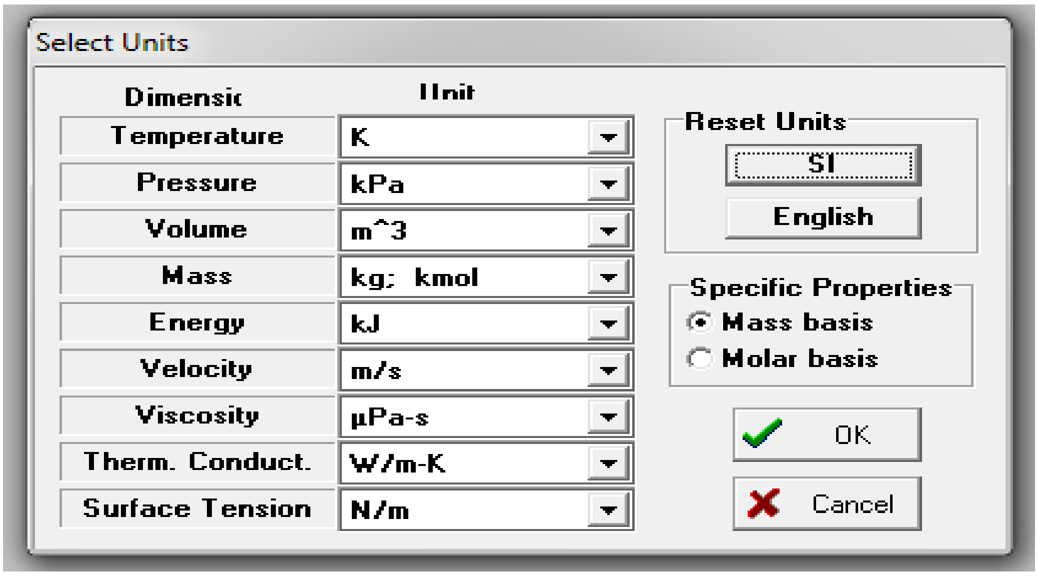
3.1 Introduction:

In this project it is worked on to reduce the ozone depletion, for which pre-defined mixture (R-508A) is selected. Further, the analysis is done for varying properties using the software Refprop which described in detail in chapter no:4.

3.2 Units:

There are two units i.e. system of units and English units. Select SI units then after select the OK button as shown in figure 3.1

International Journal of Core Engineering & Management (ISSN: 2348-9510)
Special Issue, NCETME -2017, St. Johns College of Engineering and Technology, Yemmiganur



3.3Selection of Substance:
Hereby Select R-508A from predefined mixture for the analysis purpose as shown in figure 3.2

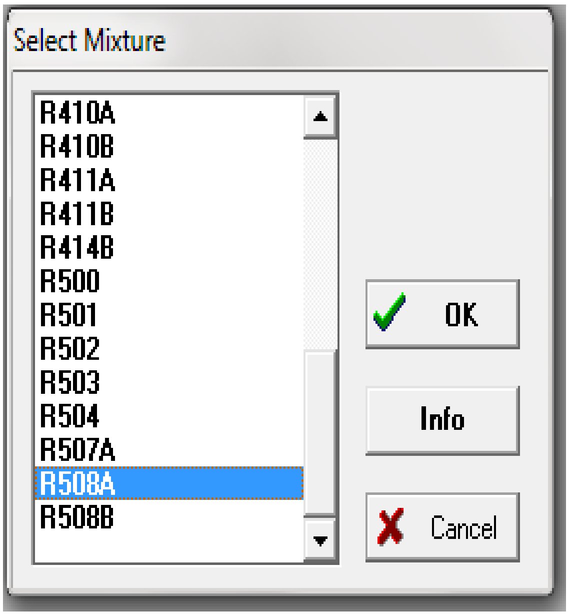


Fig 3.2 Predefined Mixture

International Journal of Core Engineering & Management (ISSN: 2348-9510)
Special Issue, NCETME -2017, St. Johns College of Engineering and Technology, Yemmiganur

3.4 Mixture Information:

These is the mixture information as shown in figure 3.3

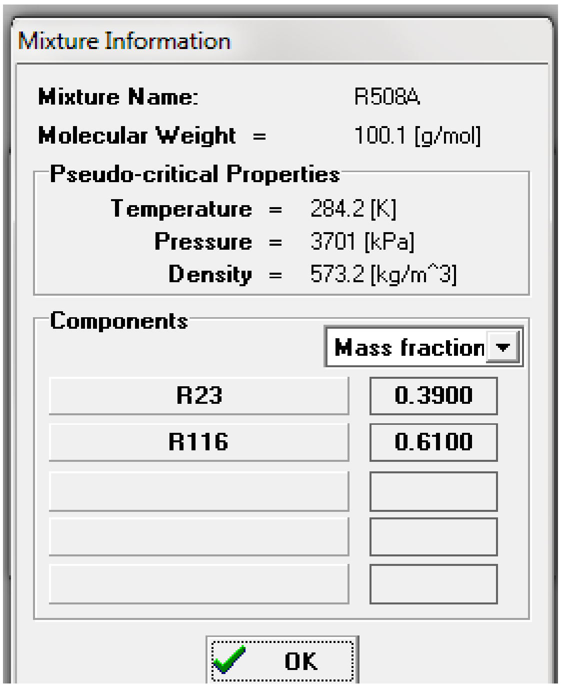


Fig no 3.3 Mixture Information

3.5 Saturation Table Calculation for R-508A and R-134A:

By varying temperature and pressure the specific saturation values of R-508A & R-134A are obtain as follows.

3.5.1 Saturation Table of R-508A at Constant Pressure:

When pressures is kept constant and temperature is varied and the result obtained is shown in figue 3.4

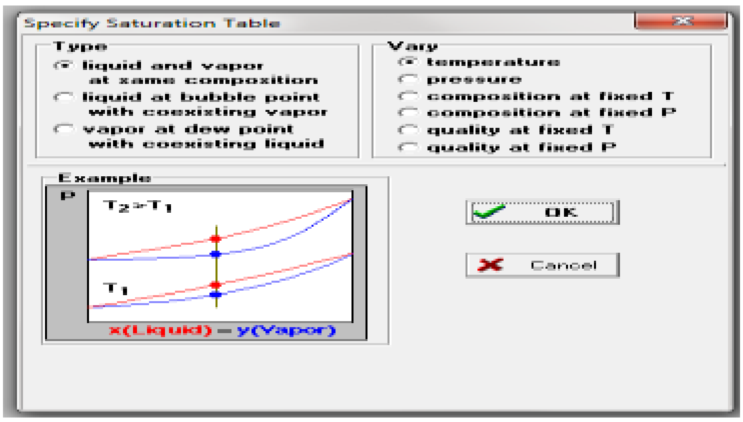


Fig no 3.4 Specify Saturation Table of R-508A at Constant Pressure

International Journal of Core Engineering & Management (ISSN: 2348-9510)
Special Issue, NCETME -2017, St. Johns College of Engineering and Technology, Yemmiganur

3.5.2 Saturation Table of R-134A at Constant Pressure:

When pressure is kept constant and temperature is varied and the result obtained is shown in figure.

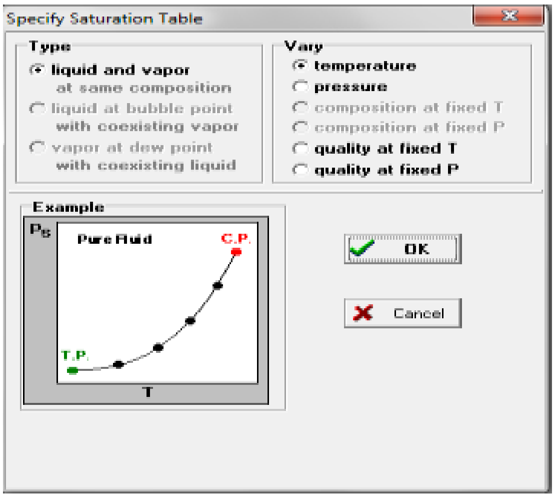


Fig no 3.5 Specify Saturation Table of R-134A at Constant Pressure.

3.6 Iso-property Table Calculation for R-508A and R-134A :-

3.6.1 Iso-property Table of R-508A at Constant Temperature:

By keeping temperature as constant and varying the pressure, the specific iso-property of R-508A is obtain as shown.

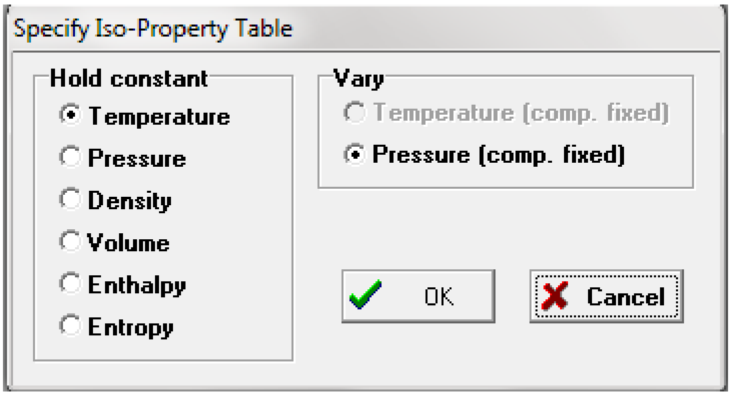


Fig no 3.6 Iso-property Information of R-508A at Constant Temperature.

International Journal of Core Engineering & Management (ISSN: 2348-9510)
Special Issue, NCETME -2017, St. Johns College of Engineering and Technology, Yemmiganur

3.6.2 Iso-property Table of R-134A at Constant Temperature:

By keeping temperature as constant and varying the pressure, the specific iso-property of R-134A is obtained as shown.

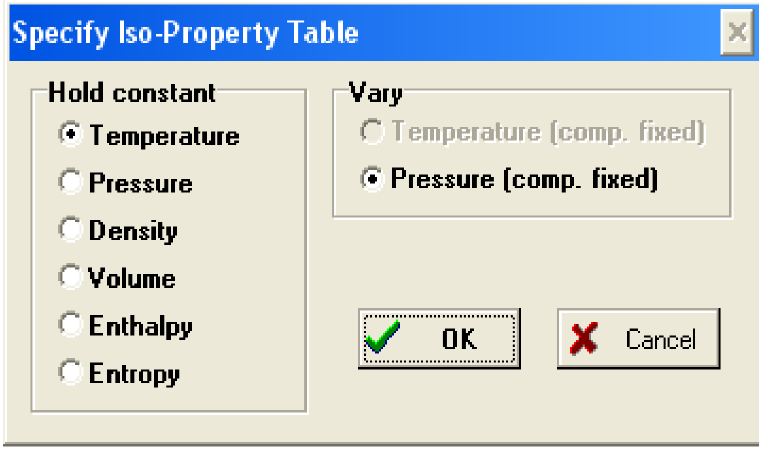


Fig no 3.7 Iso-property Table Information of R-134A at Constant Temperature.

3.7 Plot diagrams for R-508A and R-134A:

3.7.1 T-s diagram of R-508A:

T-s diagram of R-508A as shown in figure.

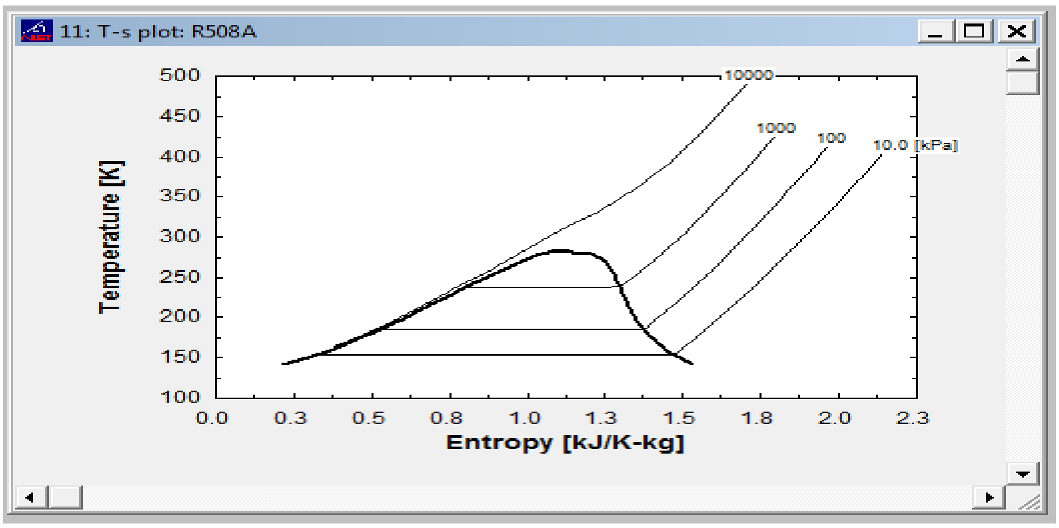


Fig.3.8 T-s diagram of R-508A.

International Journal of Core Engineering & Management (ISSN: 2348-9510)
Special Issue, NCETME -2017, St. Johns College of Engineering and Technology, Yemmiganur

3.7.2 T-s Plot diagram for R-134A :

T-s diagram of R-134A as shown in figure.

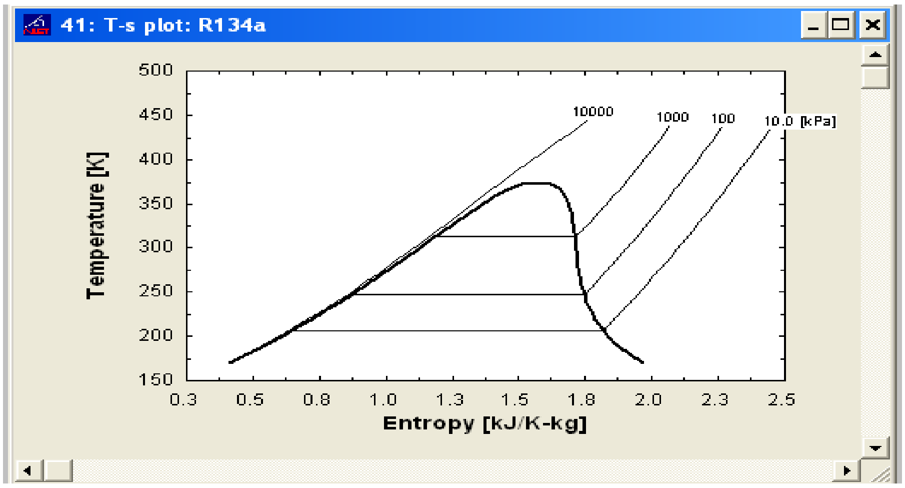


Fig.3.9 T-s diagram of R-134A.

IV. RESULTS AND DISCUSSION

4.1 Comparison between R-134A and R-508A:

4.1.1 Variation of COP with Evaporator Pressure :-

S. NO	Evaporator Pressure(kPa)	Enthalpy (kJ/kg)						COP	
		R134A			R508A				
		h1	h2	hf3=h4	h1	h2	hf3=h4	R134A	R508A
1	110	383.9	481.9	168.1	399.2	511.7	129.1	2.2	2.4
2	220	394.1	475.8	189.8	406.7	505.5	149.6	2.5	2.6
3	330	400.5	465.8	204.5	411.3	488.7	163.5	3.0	3.2
4	440	405.3	460.9	216.0	414.6	481.3	174.3	3.4	3.6
5	550	409.1	452.7	225.7	417.0	470.1	183.3	4.2	4.4

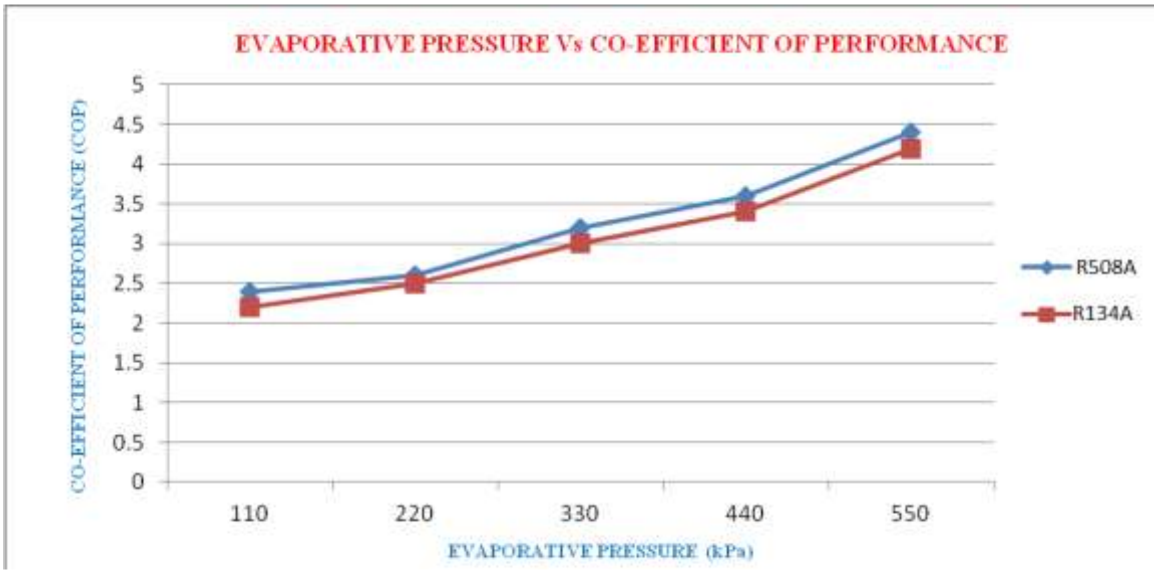


Figure no.4(a) Variation of COP with Evaporator pressure.

The above Figure shows that the variation of COP with Evaporator Pressure. For R134A when evaporator pressure increases, the COP increases. For R508A, this behaviour is similar but the values of evaporator pressure are high for the same COP used in R134A. This concludes that behaviour of R508A is better than R134A.

4.1.2 Variation of COP with Condenser Pressure :

S. NO	Condenser Pressure (kPa)	Enthalpy (kJ/kg)						COP	
		R134A			R508A			R134A	R508A
		h1	h2	hf3=h4	h1	h2	hf3=h4		
1	1190	421.9	460.0	265.5	424.4	470.7	220.3	4.1	4.4
2	1380	424.1	465.6	274.5	4254	474.8	228.7	3.6	4.0
3	1570	425.8	470.4	282.8	426.0	481.7	236.4	3.2	3.4
4	1760	427.1	489.1	290.7	426.3	496.5	243.6	2.2	2.6
5	1950	428.1	514.7	298.1	426.3	522.4	253.3	1.5	1.8

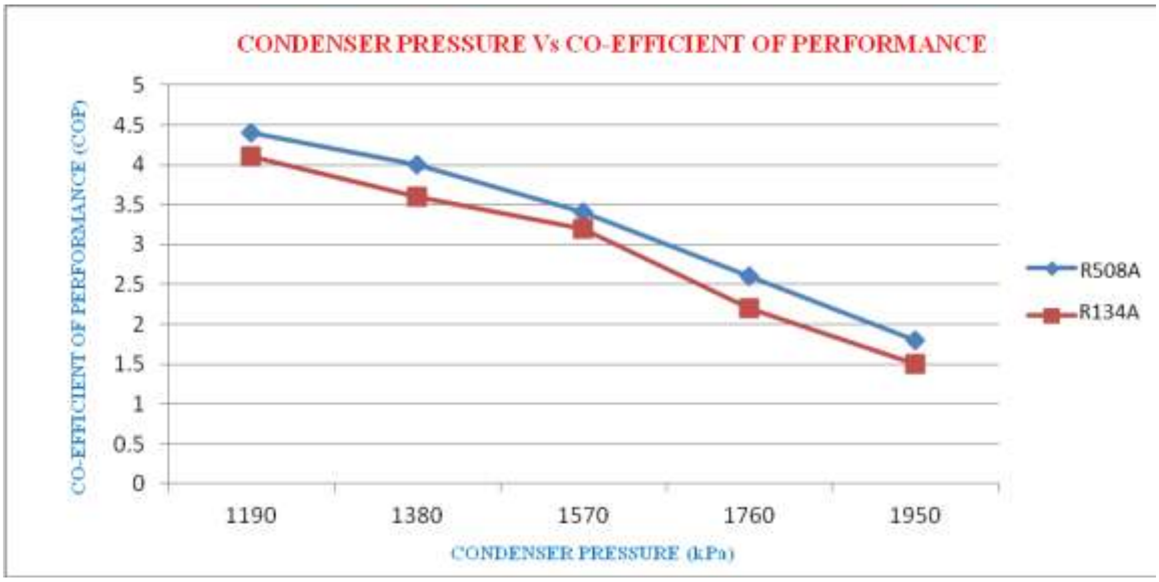


Figure no,4(b)Variation of COP with Condenser Pressure.

The above figure shows that the variation of COP with Condenser Pressure. For R134A when condenser pressure increases, the COP decreases. For R508A, this behaviour is similar but the values of condenser pressure are high for the same COP used in R134A. This concludes that behaviour of R508A is better than R134A.

4.1.3 Variation of COP with Sub cooling Temperature:

S. NO	Sub-Cooling Temperature (°C)	Enthalpy (kJ/kg)						COP	
		R134A			R508A			R134A	R508A
		h1	h2	hf3=h4	h1	h2	hf3=h4		
1	-55	365.7	463.1	131.8	386.4	497.3	98.0	2.4	2.6
2	-60	378.3	457.4	156.8	397.5	488.4	124.7	2.8	3.0
3	-65	390.8	455.8	182.6	407.6	480.6	152.1	3.2	3.5
4	-70	402.5	456.1	209.3	416.3	475.2	180.5	3.6	4.0
5	-75	413.3	457.3	237.2	422.9	471.1	210.4	4.0	4.4

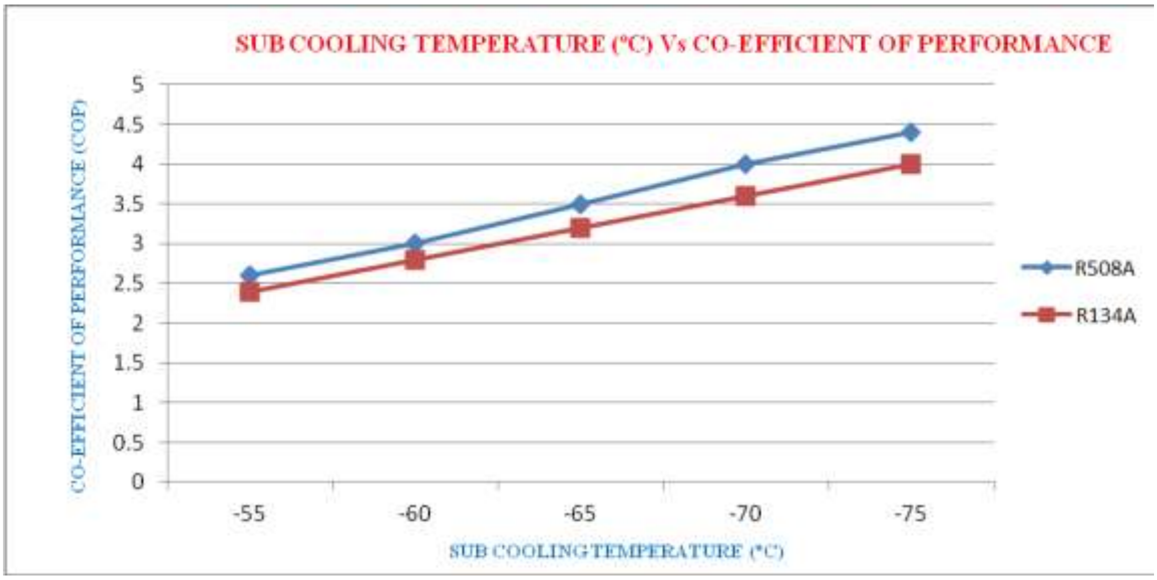


Figure no.4(c) Variation of COP with Sub cooling Temperature (° c)

The above figure shows that the variation of COP with Sub cooling temperature for R134A when sub cooling temperature decreases, the COP increases. For R508A, this behaviour is similar but the values of sub cooling temperature are high for the same COP used in R134A. This concludes that behaviour of R508A is better than R134A.

V. CONCLUSION

R-508A is refrigerant blend, with zero ozone depletion potential (ODP). It has higher volumetric cooling capacity compared to R-134A and has better thermal exchange properties.

- The overall COP of the system is 5% to 6% is more than R-134A. R-508A operates at approximately 50 to 70 percent higher pressure at the same saturated temperatures than R-134A.
- The comparison between R-134A and R-508A has been done in three ways. COP is placed against evaporator pressure, condenser pressure and sub cooling temperature. In all the situations, the COP values are high for the same evaporator pressure, condenser pressure and sub cooling temperature used in R-134A. This shows that behaviour of R-508A is better when comparing to R-134A.
- Chlorine, which is main cause for Ozone layer depletion is being released by R-134A refrigerant series air conditioners as a part of HCFC. R-508A series is remedy to avoid chlorine and found R-508A is best when compared to R-134A.

As per the proposed work the refrigerant R-508A is considered and analyzed in detail. This is done by the help on NIST software named REFPROP; the various ranges of analysis are Temperature From 200K To 320K, Pressure From 110kPa to 550kPa.

The complete analysis is carried out in S.I. units and the resultant graphs shows that the refrigerant is suitable for using in Refrigeration and Air Conditioning systems.

It may be noted that one chlorine atom can destroy 100000 ozone molecules. The relative ability of a substance to deplete the ozone layer is called ozone depletion potential (ODP). The CFC refrigerants such as R-11 and R-12 have the highest ODP=1.The HCFC refrigerants have a relatively low ODP,
i.e.R-134A has ODP=0.05.The HFC refrigerants do not cause any ozone depletion, i.e., R-508A has ODP=0 Therefore in this paper an analysis has been done on R-508A and it is concluded that R-508A is an Eco friendly refrigerant to avoid depletion of ozone layer for different applications.

REFERENCES

[1] The Ozone Cell of the Ministry of Environment & Forests (MoEF),Government of India, in co-operation with the Government of Germany represented by Deutsche Gesellschaft fur International Zusammenarbeit (GIZ) GmbH and United Nations Environment Programme (UNEP).
[2] Rani Tusha and P. Balachander, 2008. Numerical Simulation Of fin and tube condenser in a R134a system charged With R4010a, J. Scientific and Industrial Res., 67: 209-218.
[3] McLinden MO, Klein SA, Lemmon EW, Peskin AP. NIST thermodynamic and transport properties of refrigerants and refrigerant mixtures (REFPROP), Version 6.0..Gaithersburg, MD: National Institute of Standards and Technology, 1998.
[4] Chang SD, Ro ST. Pressure drop of pure HFC refrigerants and their mixtures flowing in capillary tubes. Int J Multiphase Flow 1996;22(3):551–6
1.
[5] Manual as energy Efficiency at design stage, CII Godrej Energy Management Cell-1998 edition
[6] CII-Godrej Green Business Centre – HVAC 0 &M Manual
[7] Adnan Sozen, Erol Arcakliog lu, Tayfun Menli_k and Mehmet Ozalp, 2008. Determination of thermodynamic properties of an alternative refrigerant (R407c) using artificial neural network, Expert Systems with Applications.