Analysis Of Hydro Fluoro Carbons To Reduce Ozone Depletion

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ABSTRACT: *Ozone depletion is one of greatest disasters today. It is familiar to most of us that Hydro Chloro Fluoro Carbons (HCFC) is main reason. Air conditioners are the sources* of HCFC. *Refrigerants known as CFC12 (R12) and HCFC22 (R22) are stable, remain in the atmosphere for many years, and eventually diffuse into the stratosphere. In the upper atmosphere the refrigerant molecules breakdown and release chlorine, which destroys the ozone layer. In the lower atmosphere the molecules absorb infrared radiation and contribute to global warming. Each chlorine atom released can destroy up to 100,000 ozone molecules before it is removed from the stratosphere. Objective of this project is to present Air conditioners which don't use* chlorine; *they just release Hydro Fluoro Carbons (HFC's) instead* of Hydro *Chloro Fluoro Carbons (HCFC's).There are different types of refrigerants used in refrigeration and air-conditioning plants. The refrigerant R-22 which is extensively used in air conditioners belongs to HCFC group, which is to be phased out by 2040. These refrigerants are responsible for Ozone Depletion to a greater extent. It includes chlorine which is the main reason for the depletion of Ozone layer, it is found R 407C is best when compare to that, as this avoids chlorine. Therefore in this paper an analysis has been done on R407c and it is concluded that R407c is an Eco friendly refrigerant to avoid depletion of ozone layer for different applications.*

Keywords: *Air conditioning, Hydro fluoro carbons, Ozone layer, Refrigerants, Refprop software,*

1. INTRODUCTION:

1.1 AIR CONDITIONING:

Air conditioning is the removal of heat from indoor air for thermal comfort. In another sense, the term can refer to any form of cooling, heating, ventilation, or disinfection that modifies the condition of air. An air conditioner (often referred to as AC or air con.) is an appliance, system , or machine designed to change the air temperature and humidity within an area (used for cooling as well as heating depending on the air properties at a given time), typically using a refrigeration cycle but sometimes using evaporation, commonly for comfort cooling in buildings.

1.2 Air-conditioning applications:

Air-conditioning engineers broadly divide air-conditioning applications into what they call comfort and process applications. Comfort applications aim to provide a building indoor environment that remains relatively constant despite changes in external weather conditions or in internal heat loads. Air conditioning makes deep plan buildings feasible, for otherwise they would have to be built narrower or with light wells so that inner spaces received sufficient outdoor air via natural ventilation. Air conditioning also allows buildings to be taller, since wind speed increases significantly with altitude making natural ventilation impractical for very tall buildings.

2. LITERATURE SURVEY:

Let's take a trip back in time about 3,000 years ago. Of course we'll have to get rid of our cell phones, I-Pods and computers; these cool toys won't do us any good here. The top responses would be "electricity", "running water" and "transportation". With good reason, these answers top the list in most cases but there is one that seems to elude the top of the list and gets little respect for its' impact on the world we live in...Refrigeration. There is no doubt that many inventions have had an impact on our lives but refrigeration and the ability to control our environment has had a much deeper impact than we give it credit for. From ancient food storage techniques to the modern day central air conditioning system, the following will provide you a whole new appreciation for the science and importance of refrigeration.

2.1The Origin of Mechanical Refrigeration:

Mechanical refrigeration was discovered much by accident. In the late 1800's, coal mines in England were pumping fresh air into the deep shafts of the mines using steam driven compressors. After running these compressors for a long period of time, ice would begin to form on the nozzles of the hoses that carried the air. Here is where the possibilities became endless.

Again sparing the in depth science involved, this is where it was discovered that the temperature, more specifically the boiling points, of certain liquids and gasses could be manipulated by changing the pressure under which they are kept. Now aside from using a fan to blow air over a bucket of ice, this became the science behind mechanical refrigeration and how we could produce it without the direct involvement of ice.

Fig no. 2.1.The window air conditioner. Many of which end up here because of improper storage and maintenance.

Fig no.2.2 The condenser in a central air system.

Fig no.2.3 A stack of roof top units for mid-sized commercial buildings.

3. REFRIGERANTS:

The thermodynamic efficiency of a refrigeration system depends mainly on its operating temperatures. However, important practical issues such as the system design, size, initial and operating costs, safety, reliability, and serviceability etc. depend very much on the type of refrigerant selected for a given application. Due to several environmental issues such as ozone layer depletion and global warming and their relation to the various refrigerants used, the selection of suitable refrigerant has become one of the most important issues in recent times. Replacement of an existing refrigerant by a completely new refrigerant, for whatever reason, is an expensive proposition as it may call for several changes in the design and manufacturing of refrigeration systems. Hence it is very important to understand the issues related to the selection and use of refrigerants. In principle, any fluid can be used as a refrigerant. Air used in an air cycle refrigeration system can also be considered as a refrigerant. However, in this lecture the attention is mainly focused on those fluids that can be used as refrigerants in vapour compression refrigeration systems only.

3.1 IMPORTANCE OF OZONE LAYER:

Ozone present in the stratosphere forms a protective layer and known as ozone layer, ozonosphere or ozone umbrella...... Its concentration in atmosphere is about 10 ppm. In the upper atmosphere, atmospheric gases absorb the sun's radiation, get ionized, and release molecules. In lower atmosphere, atmospheric oxygen gets dissociated and subsequently combines with molecular oxygen of the upper stratosphere, there by producing ozone.

O_2----- (UVradiation) ---->O+O
O_2 + O -----------> O_3

The presence of ozone layer in the stratosphere is of vital significance for all biota, as it absorbs the harmful ultraviolet radiations which are lethal to life......

O_3 + UV radiations--------> O_2 + O

The ozone absorbs ultraviolet radiation and prevent them to reach earth's surface. If these radiations are allowed to reach the earth's atmosphere they will increase the temperature of lower atmosphere to such an extent, that it will be impossible for any life to survive on earth. These UV radiations can cause severe radiation damage in human and animals such as DNA mutation and skin cancer.

4. REF-PROP SOFTWARE:

4.1 Objectives and Scope of the Database:

REFPROP is an acronym for REFerence fluid PROPerties. This program, developed by the National Institute of Standards and Technology (NIST), calculates the thermodynamic and transport properties of industrially important fluids and their mixtures. These properties can be displayed in tables and plots through the graphical user interface; they are also accessible through spreadsheets or user-written applications accessing the REFPROP DLL or the FORTRAN property subroutines.REFPROP is based on the

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most accurate pure fluid and mixture models currently available.

5. RESULTS AND DISCUSSION:

5.1 Introduction:

In this paper it is worked on to reduce the ozone depletion, for which pre-defined mixture (R-407C) is selected. Further, the analysis is done for varying properties using the software Refprop.

5.2 Selection of Substance:

Hereby Select R 407C from predefined mixture for the analysis purpose as shown.

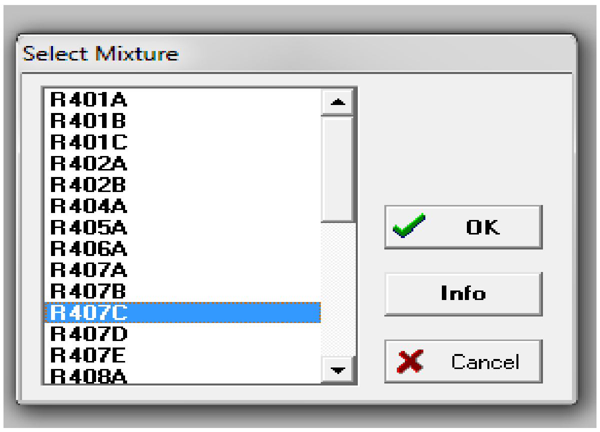

Fig 5.1 Predefined Mixture

5.3 Mixture Information:

This is the mixture information as shown.

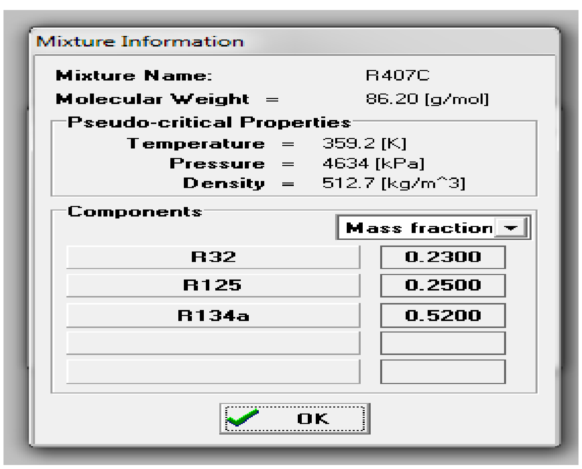

Fig no 5.2 Mixture Information

5.4 Saturation Tables Calculation for R-22 and R-407C:

5.4.1 Specify Saturation Table of R-22C at Constant Pressure:

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

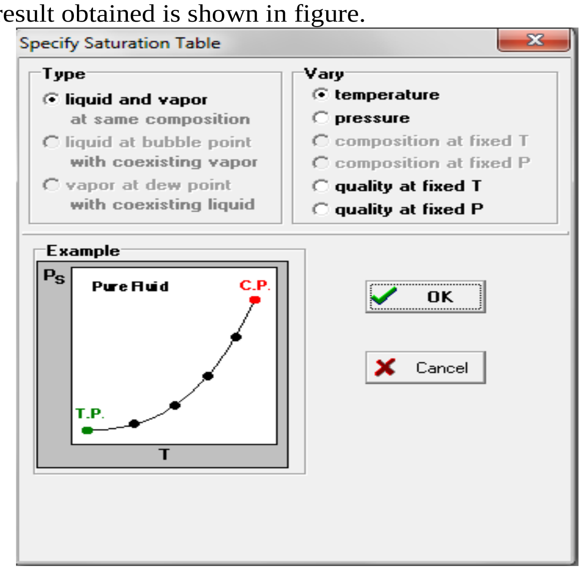

Fig no 5.3 Specify Saturation Table of R-22 at Constant Pressure

5.4.2 Saturation Table Information of R-22 at Constant Pressure:

Initial temperature is 220 K and final temperature is 340K by increment of 20K as shown in figure.

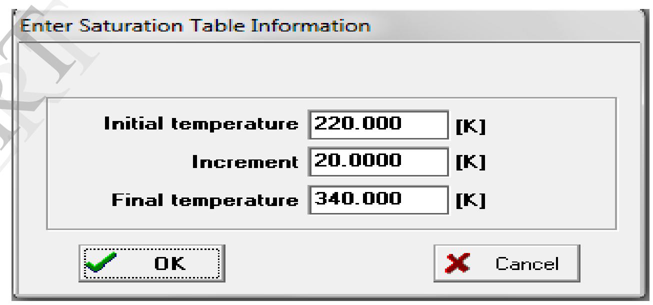

Fig no 5.4 Saturation Table Information of R-22 at Constant Pressure

5.4.3 Saturation Table of R-22C at Constant Pressure:

These are the properties of R-22 as shown in table 5.1

Table no 5.1 Saturation Table of R22 at Constant Pressure

REFPROP - NIST Refrigerant Properties Database - [1: R22: L/V sat. T=220.0 to 340.0 [K]]

File Edit Options Substance Calculate Plot Window Help

	Temp [K]	Pressure [kPa]	Density (L) [kg/m³]	Density (V) [kg/m³]	Enthalpy (L) [kJ/kg]	Enthalpy (V) [kJ/kg]	Entropy (L) [kJ/K-kg]
1	220.0	54.73	1445	2.649	140.6	381.9	0.7599
2	240.0	143.2	1387	6.501	162.4	391.3	0.8544
3	260.0	316.9	1325	13.76	184.8	399.9	0.9435
4	280.0	618.6	1258	26.23	208.1	407.5	1.029
5	300.0	1097	1183	46.54	232.6	413.5	1.112
6	320.0	1806	1097	79.19	258.9	417.2	1.195
7	340.0	2808	990.1	133.9	288.1	416.8	1.280

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5.4.4 Specify Saturation Table of R-22 at Constant Temperature:

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

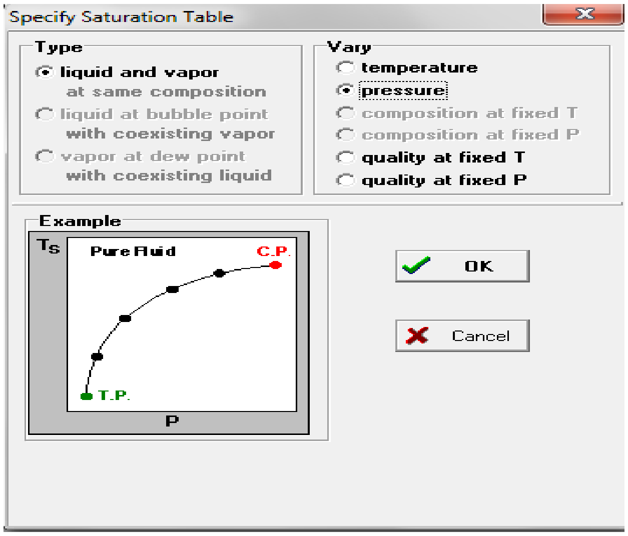

Fig no 5.5 Specify Saturation Table of R 22 at Constant Temperature

5.4.5 Saturation Table Information of R 22 at Constant Temperature:

Initial pressure is 110kPa and final pressure is 770kPa by increment of 110kPa as shown in figure.

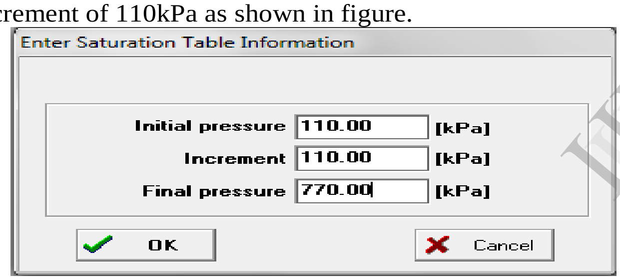

Fig no 5.6 Saturation Table Information of R 22 at Constant Temperature

5.4.6 Saturation Table of R 22 at Constant Temperature:

These are the properties of R 22 as shown in table 5.2

Table no 5.2 Saturation Table of R 22 at Constant Temperature

REFPROP - NIST Refrigerant Properties Database - [1: R22: L/V sat. P=110.0 to 770.0 [kPa]]

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	Pressure [kPa]	Temp [K]	Density (L) [kg/m3]	Density (V) [kg/m3]	Enthalpy (L) [kJ/kg]	Enthalpy (V) [kJ/kg]	Entropy (L) [kJ/K-kg]	Entropy (V) [kJ/K-kg]
1	110.0	234.1	1404	5.079	155.9	388.6	0.8272	1.821
2	220.0	250.4	1355	9.735	173.9	395.9	0.9011	1.788
3	330.0	261.1	1321	14.30	186.1	400.4	0.9484	1.769
4	440.0	269.4	1294	18.84	195.6	403.6	0.9840	1.756
5	550.0	276.2	1271	23.38	203.6	406.2	1.013	1.746
6	660.0	282.1	1250	27.95	210.6	408.2	1.038	1.738
7	770.0	287.3	1232	32.55	216.9	409.9	1.059	1.731

5.4.7 Specify Saturation Table of R407C at Constant Pressure:

When pressures is kept constant and temperature is varied and the result obtained is shown in figure 5.6

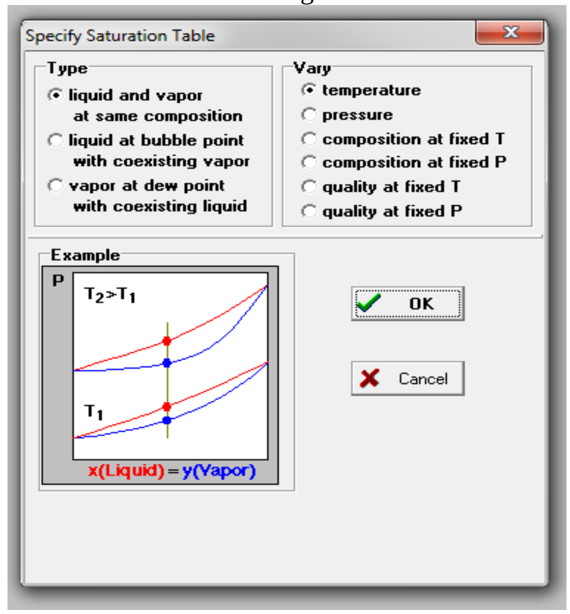

Fig no 5.7 Specify Saturation Table of R407C at Constant Pressure

5.4.8 Saturation Table Information of R407C at Constant Pressure:

Initial temperature is 220 K and final temperature is 340K by increment of 20K as shown in figure 5.7

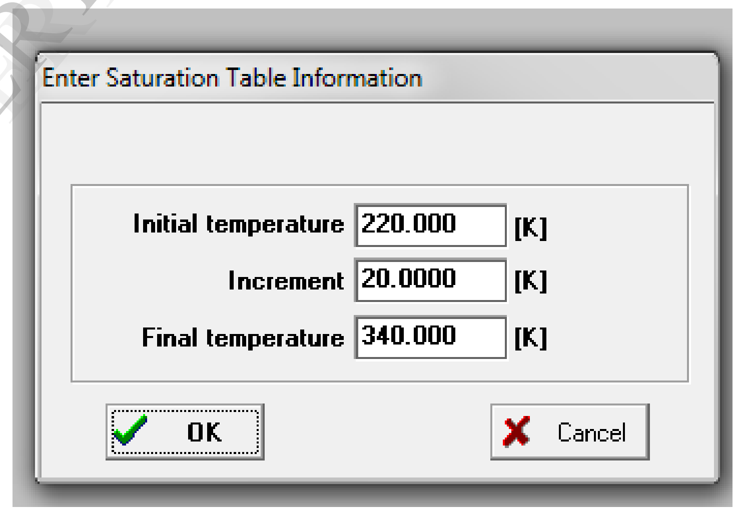

Fig no 5.8 Saturation Table Information of R407C at Constant Pressure

5.4.9 Saturation Table of R407C at Constant Pressure:

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These are the properties of R 407C as shown in table 5.1

Table no 5.3 Saturation Table of R407C at Constant Pressure

REFPROP - NIST Refrigerant Properties Database - [7: R407C: L/V sat. T=220.0 to 340.0 [K]]

	Temp [K]	Pressure (L) [kPa]	Pressure (V) [kPa]	Density (L) [kg/m³]	Density (V) [kg/m³]	Enthalpy (L) [kJ/kg]	Enthalpy (V) [kJ/kg]	Entropy (L) [kJ/K-kg]
1	220.0	63.40	42.22	1410	2.035	128.9	379.1	0.7124
2	240.0	164.5	120.3	1349	5.443	154.9	391.0	0.8251
3	260.0	362.2	283.7	1283	12.31	181.7	402.1	0.9321
4	280.0	704.8	581.9	1211	24.78	209.8	412.1	1.035
5	300.0	1248	1075	1130	46.25	239.4	420.2	1.135
6	320.0	2055	1835	1032	83.10	271.5	425.3	1.237
7	340.0	3196	2958	900.1	151.9	308.1	424.3	1.344

5.4.10 Specify Saturation Table of R 407C at Constant Temperature:

When temperature is kept constant and pressures is varied and the result obtained is shown.

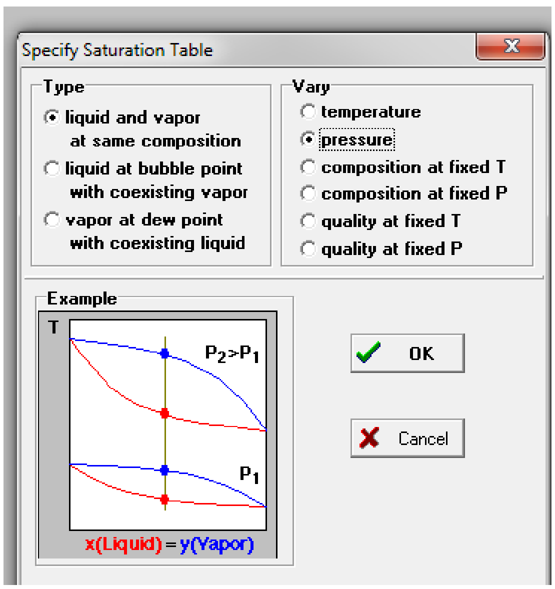

Fig no 5.9 Specify Saturation Table of R 407C at Constant Temperature

5.4.11 Iso-property Table Information of R 407C at Constant Temperature:

Initial pressure is 110KPa and final pressure is 2310KPa by increment of 110KPa as shown.

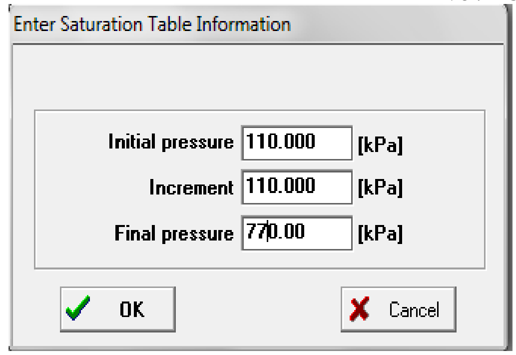

Fig no 5.10 Saturation Table Information of R 407C at Constant Temperature

5.4.12 Saturation Table of R 407C at Constant Temperature:
These are the properties of R 407C as shown in table 5.2

Table no 5.4 Saturation Table of R 407C at Constant Temperature

REFPROP - NIST Refrigerant Properties Database - [2: R407C: L/V sat. P=110.0 to 770.0 [kPa]]

	Pressure [kPa]	Temp (L) [K]	Temp (V) [K]	Density (L) [kg/m³]	Density (V) [kg/m³]	Enthalpy (L) [kJ/kg]	Enthalpy (V) [kJ/kg]	Entropy (L) [kJ/K-kg]
1	110.0	231.1	238.1	1377	5.003	143.2	389.9	0.7756
2	220.0	247.0	253.7	1327	9.650	164.1	398.7	0.8629
3	330.0	257.5	263.9	1292	14.24	178.2	404.2	0.9187
4	440.0	265.5	271.8	1264	18.82	189.3	408.2	0.9608
5	550.0	272.2	278.3	1240	23.44	198.6	411.3	0.9950
6	660.0	277.9	283.9	1219	28.10	206.7	413.8	1.024
7	770.0	282.9	288.8	1200	32.81	214.0	415.9	1.050

5.5 Iso-property Table Calculation for R 22 and R 407C:

5.5.1 Specify Iso-property Table of R 22 at Constant Temperature:

By keeping temperature as constant and varying the pressure, the specific iso-property of R 22 is obtain as shown.

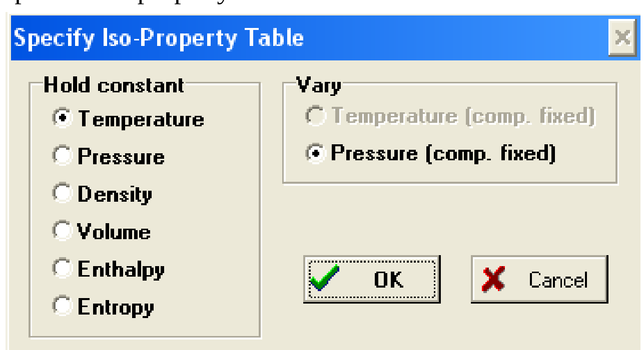

Fig no 5.11 Iso-property Table Information of R 22 at Constant Temperature

5.5.2 Iso-property Table Information of R 22 at Constant Temperature:

Initial pressure is 110KPa and final pressure is 770kPa by increment of 110KPa as shown in figure 5.10

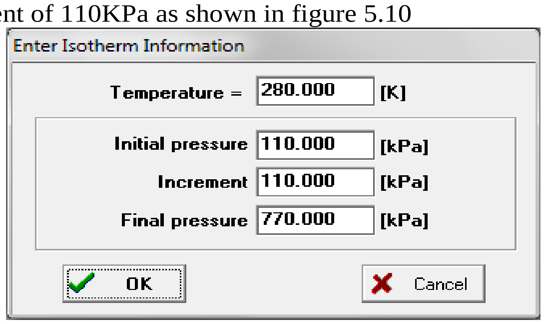

Fig no 5.12 Iso-property Table Information of R 22 at Constant Temperature

5.5.3 Iso-property Table of R 22 at Constant Temperature:

These are the iso-properties of R 22 at T=280K

Table no 5.5 Iso-property Table of R 22 at Constant Temperature

REFPROP - NIST Refrigerant Properties Database - [3: R22: T=280.0 [K]]

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	Temp [K]	Pressure [kPa]	Density [kg/m3]	Enthalpy [kJ/kg]	Entropy [kJ/K-kg]	Quality [mol/mol]	Mass frac. [R22]
1	280.0	110.0	4.168	417.3	1.933	superheated	1.0000
2	280.0	220.0	8.515	415.4	1.861	superheated	1.0000
3	280.0	330.0	13.07	413.4	1.817	superheated	1.0000
4	280.0	440.0	17.85	411.3	1.784	superheated	1.0000
5	280.0	550.0	22.91	409.0	1.756	superheated	1.0000
6	280.0	660.0	1258	208.1	1.029	subcooled	1.0000
7	280.0	770.0	1259	208.1	1.029	subcooled	1.0000

5.5.4 Specify Iso-property Table of R 22 at Constant Pressure:

By keeping pressure as constant and varying the temperature, the specific iso-property of R 22 is obtain as shown.

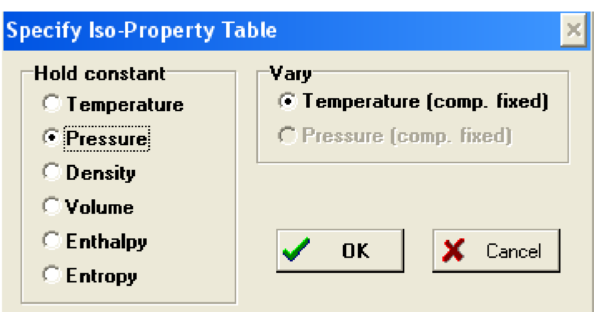

Fig no 5.13 Iso-property Table Information of R 22 at Constant Pressure

5.5.5 Iso-property Table Information of R 22 at Constant Pressure:

Initial temperature is 220K and final temperature is 340K with an increment of 20K as shown.

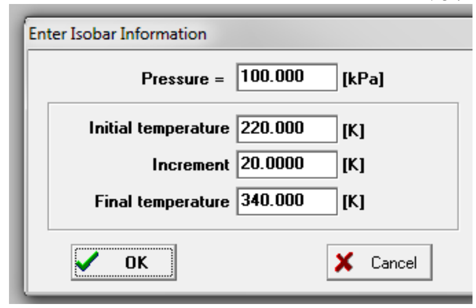

Fig no 5.14 Iso-property Table Information of R 22 at Constant Pressure

5.5.6 Iso-property Table of R 22 at Constant Pressure:

These are the iso-properties of R 22 at constant P=100kPa

Table no 5.6 Iso-property Table of R 22 at Constant Pressure

REFPROP - NIST Refrigerant Properties Database - [4: R22: P=100.0 [kPa]]

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	Temp [K]	Pressure [kPa]	Density [kg/m3]	Enthalpy [kJ/kg]	Entropy [kJ/K-kg]	Quality [mol/mol]	Mass frac. [R22]
1	220.0	100.0	1445	140.6	0.7599	subcooled	1.0000
2	240.0	100.0	4.473	392.4	1.846	superheated	1.0000
3	260.0	100.0	4.096	404.8	1.896	superheated	1.0000
4	280.0	100.0	3.782	417.5	1.943	superheated	1.0000
5	300.0	100.0	3.516	430.6	1.988	superheated	1.0000
6	320.0	100.0	3.287	444.0	2.031	superheated	1.0000
7	340.0	100.0	3.087	457.9	2.073	superheated	1.0000

5.5.7 Specify Iso-property Table of R 407C at Constant Temperature:

By keeping temperature as constant and varying the pressure, the specific iso-property of R 407C is obtain as shown.

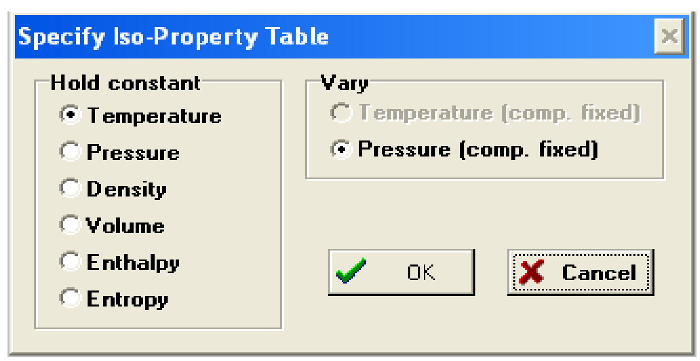


Fig no 5.15 Iso-property Table Information of R 407C at Constant Temperature

5.5.8 Iso-property Table Information of R 407C at Constant Temperature:

Initial pressure is 110KPa and final pressure is 770kPa by increment of 110KPa as shown in figure 5.10

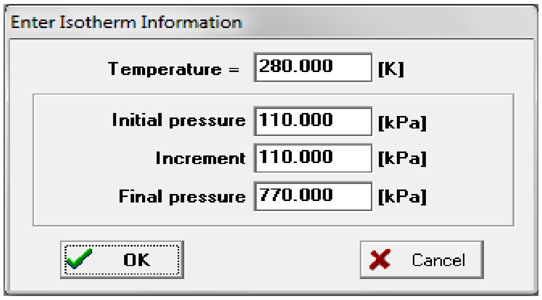
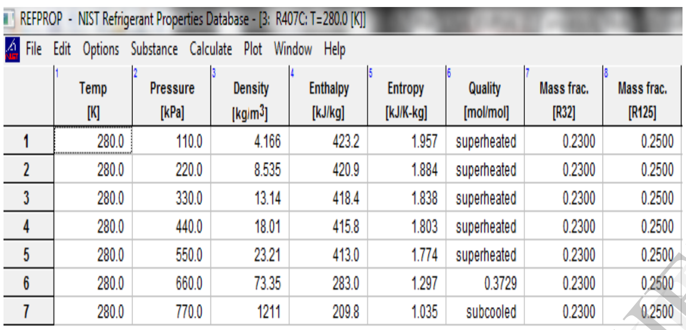


Fig no 5.16 Iso-property Table Information of R 407C at Constant Temperature

5.5.9 Iso-property Table of R 407C at Constant Temperature:

These are the iso-properties of R 407C at T=280K

Table no 5.7 Iso-property Table of R 407C at Constant Temperature


REFPROP - NIST Refrigerant Properties Database - [3: R407C: T=280.0 [K]]

File Edit Options Substance Calculate Plot Window Help

	Temp [K]	Pressure [kPa]	Density [kg/m3]	Enthalpy [kJ/kg]	Entropy [kJ/K-kg]	Quality [mol/mol]	Mass frac. [R32]	Mass frac. [R125]
1	280.0	110.0	4.166	423.2	1.957	superheated	0.2300	0.2500
2	280.0	220.0	8.535	420.9	1.884	superheated	0.2300	0.2500
3	280.0	330.0	13.14	418.4	1.838	superheated	0.2300	0.2500
4	280.0	440.0	18.01	415.8	1.803	superheated	0.2300	0.2500
5	280.0	550.0	23.21	413.0	1.774	superheated	0.2300	0.2500
6	280.0	660.0	73.35	283.0	1.297	0.3729	0.2300	0.2500
7	280.0	770.0	1211	209.8	1.035	subcooled	0.2300	0.2500

5.5.10 Specify Iso-property Table of R 407C at Constant Pressure:

By keeping pressure as constant and varying the temperature, the specific iso-property of R 407C is obtain as shown.

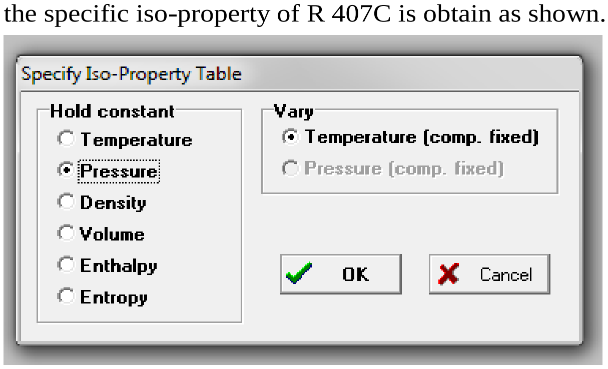


Fig no 5.17 Iso-property Table Information of R 407C at Constant Pressure

5.5.11 Iso-property Table Information of R 407C at Constant Pressure:

Initial temperature is 220K and final temperature is 340K with an increment of 20K as shown.

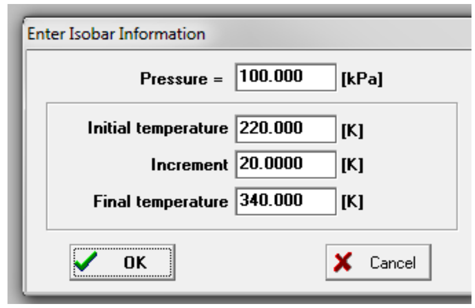
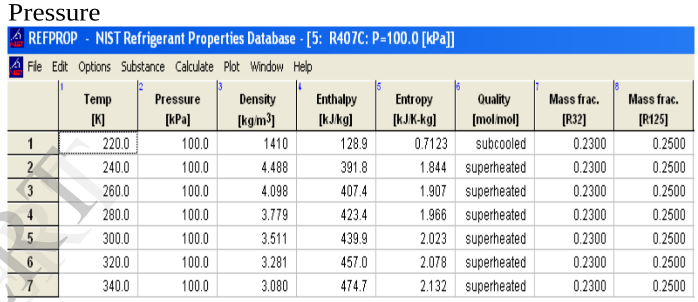


Fig no 5.18 Iso-property Table Information of R 407C at Constant Pressure

5.5.12 Iso-property Table of R 407C at Constant Pressure:

These are the iso-properties of R 407C at constant P=100kPa

Table no 5.8 Iso-property Table of R 407C at Constant Pressure


REFPROP - NIST Refrigerant Properties Database - [5: R407C: P=100.0 [kPa]]

File Edit Options Substance Calculate Plot Window Help

	Temp [K]	Pressure [kPa]	Density [kg/m3]	Enthalpy [kJ/kg]	Entropy [kJ/K-kg]	Quality [mol/mol]	Mass frac. [R32]	Mass frac. [R125]
1	220.0	100.0	1410	128.9	0.7123	subcooled	0.2300	0.2500
2	240.0	100.0	4.488	391.8	1.844	superheated	0.2300	0.2500
3	260.0	100.0	4.098	407.4	1.907	superheated	0.2300	0.2500
4	280.0	100.0	3.779	423.4	1.966	superheated	0.2300	0.2500
5	300.0	100.0	3.511	439.9	2.023	superheated	0.2300	0.2500
6	320.0	100.0	3.281	457.0	2.078	superheated	0.2300	0.2500
7	340.0	100.0	3.080	474.7	2.132	superheated	0.2300	0.2500

5.6 Plot diagrams for R-22 andR 407C:

5.6.1 T-s Plot diagram for R 22:

T-s diagram of R 22 as shown in figure.

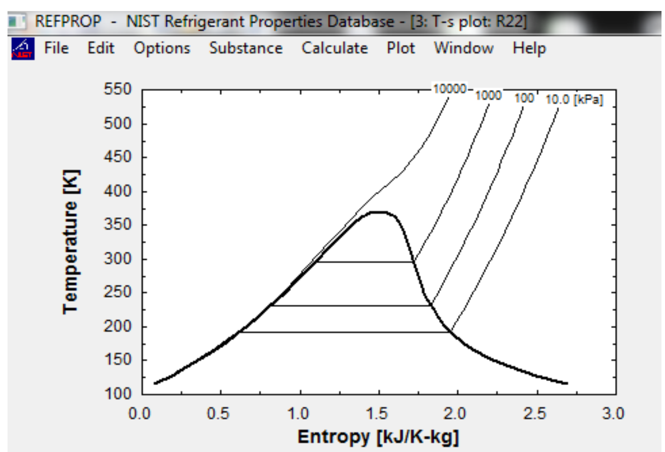


Fig.5.15 T-s diagram of R 22

5.6.2 P-h Plot diagram for R 22:

P-h diagram of R 22 as shown in figure 5.24

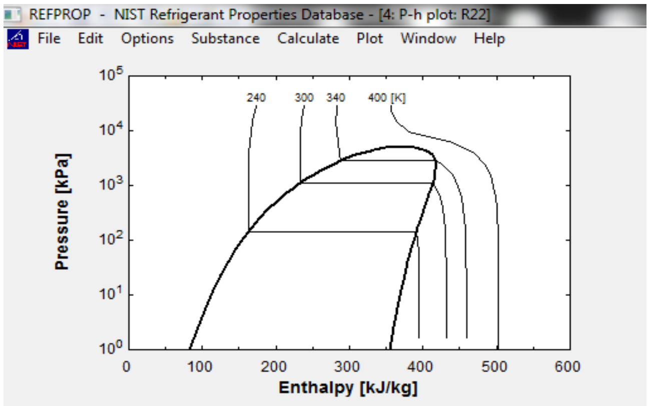


Fig no 5.16 P-h diagram of R 22

5.6.3 P-h Plot diagram for R-22(Includes lines of Constant Entropy):

P-h diagram of R 22 with constant entropy lines as shown in figure.

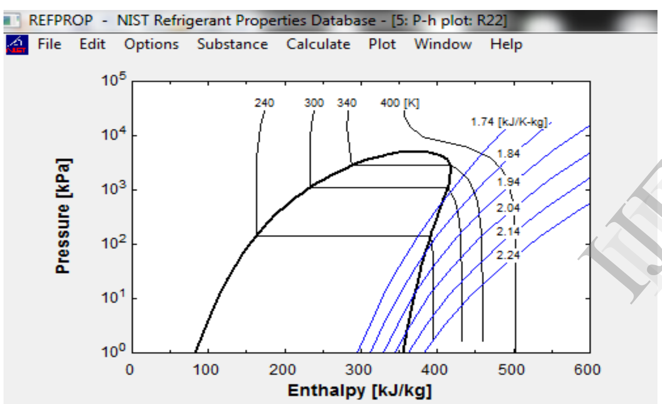


Fig no 5.17 P-h Diagram of R 407C with Constant Entropy Lines

5.6.4 T-s diagram of R 407C :

T-s diagram of R 407C as shown in figure.

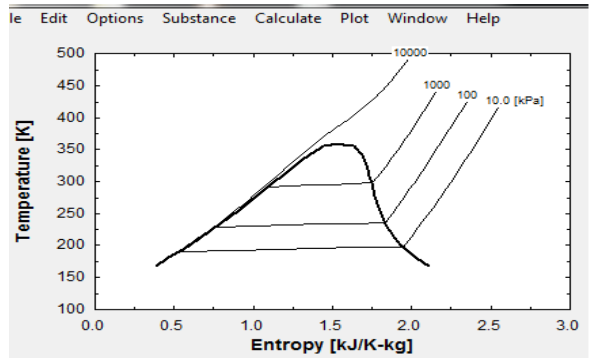


Fig.5.18 T-s diagram of R 407C

5.6.5 P-h Plot diagram for R 407 C:

P-h diagram of R 407C as shown in figure.

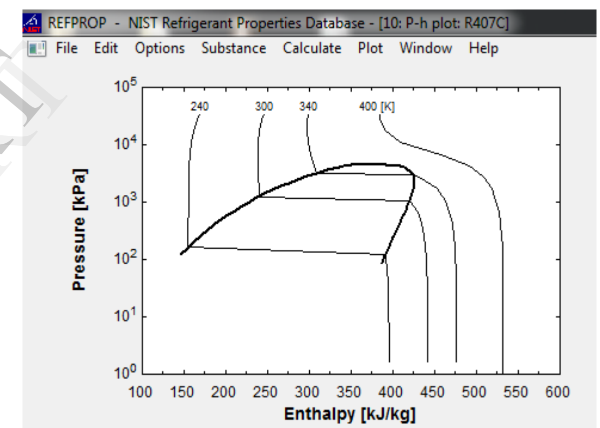


Fig.5.19 P-h diagram of R 407C

5.6.6. P-h Plot diagram for R-407C (Includes lines of Constant Entropy):

P-h diagram of R 407C with constant entropy lines as shown.

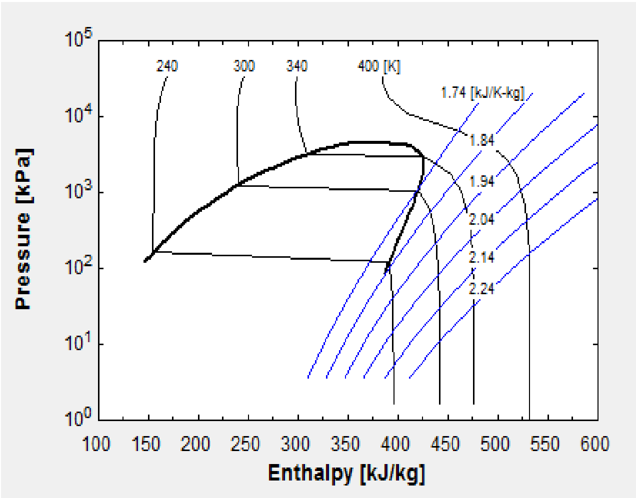


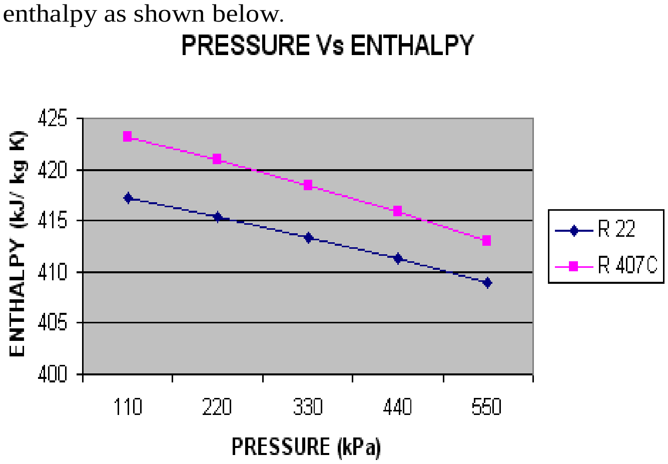
Fig no 5.20 P-h Diagram of R 407C with Constant Entropy Lines

5.7 Comparison between R 22 and R 407C:

5.7.1 Comparison graph between R 22 and R 407C at constant temperature 280 K when varying pressure and enthalpy as shown below.

PRESSURE (kPa)	ENTHALPY (kJ/ kg)	
	R 22	R 407C
110	417.3	423.2
220	415.4	420.9
330	413.4	418.4
440	411.3	415.8
550	409	413

At constant temperature 280K and when varying pressure and enthalpy as shown below.

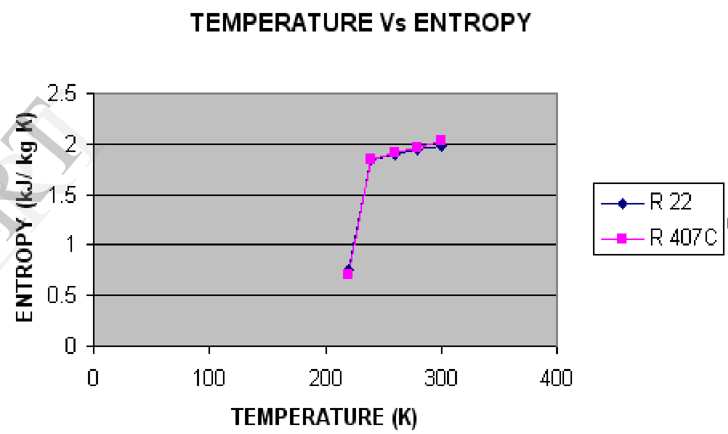


This graph depicts the comparison between R22 and R407C. At constant temperature 280K for R22 when pressure increases and the enthalpy decreases. For R407C , this behaviour is similar but the values of enthalpy are high for the same pressure used in R22. This concludes that behaviour of R407C is better when comparing to R22.

5.7.2 Comparison graph between R 22 and R 407C at constant pressure 100kPa and when varying temperature and entropy as shown below.

TEMPERATURE (K)	ENTROPYPY (kJ/ kgK)	
	R 22	R 407C
220	0.7599	0.7123
240	1.846	1.844
260	1.896	1.907
280	1.943	1.966
300	1.988	2.023

At constant pressure 100kPa and when varying temperature and entropy as shown below.



This graph depicts the comparison between R22 and R407C. At constant pressure 100kPa for R22 when temperature increases and the entropy increases. For R407C, this behaviour is similar but the values of enthalpy are high for the same temperature used in R22. This concludes that behaviour of R407C is better when comparing to R22.

CONCLUSION:

The comparison between R22 and R407C has been done in two ways. Entropy is placed against temperature and enthalpy is placed against pressure. In both the situations the behaviour is similar but for R407C, the enthalpy or entropy values are high for the same temperature and pressure used in R22. This shows that behaviour of R407C is better when comparing to R22. Chlorine, which is main cause for Ozone layer depletion is being released by R22 refrigerant series air conditioners as a part of HCFC. R407C series is remedy to avoid chlorine and found R407C is best when compared to R 22.

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As per the proposed work the refrigerant R407c 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 220K To 340K, Pressure From 100kPa to 770kPa.

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-22 has ODP=0.05.The HFC refrigerants do not cause any ozone depletion, i.e.R-134a and R407c has ODP=0.

Therefore in this paper an analysis has been done on R407c and it is concluded that R407c is an Eco friendly refrigerant to avoid depletion of ozone layer for different applications

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