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"REPLACEMENT OF R-134a WITH ENVIRONMENT FRIENDLY REFRIGERANT IN VAPOUR COMPRESSION REFRIGERATION CYCLE"

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ABSTRACT

R134a (1,1,1,2-tetrafluoroethane) has been used in domestic as well as commercial purpose in many vapour compression refrigeration system. Although it has zero ozone depleting potential but its high global warming potential of 1300 is a serious issue. Due to that high it needs to phase out from vapour compression refrigeration(VCR) cycle. The EU(European union) F-gas regulation has taken effect from January 1,2015. The regulation implies or applied an HFC(hydrofluoro carbon) phase-down from 2015 to 2030 by means of bans on high GWP refrigerants. R134a is especially under pressure and more likely to be phased out (not to be used) of all commercial systems.

This paper explains the possible replacement of R134a from vapour compression refrigeration cycle.

The basis of replacement is to analyze an ice plant working on R134a as refrigerant. Pressure and temperature reading of the plant has been taken. Based on the working pressure and temperature theoretical cop of the plant is calculated using P-h chart of R134a. R134a is replaced with mixture of three refrigerant R32, R152a and R245a in definite proportion. All the three refrigerant replacing R134a have global warming potential less than R134a. mixture of refrigerant obtained to replace R134a is analyzed on the basis of their COP, GWP, their density, enthalpy and entropy in liquid as well as in vapour phase. Based on our experimental analysis two refrigerant can be selected as possible replacement of R-134a namely M1 and M2 having R32, R152a and R245a in ratio by mass as 0.1:0.4:0.5 and 0.1:0.5:0.4 respectively. Also due comparatively low GWP, M2 composition can be suggested as best possible replacement out of M1 and M2.

Keyword: *ODP, GWP, COP, R152a, R134a.REFPROP SOFTWARE,HFC*

I. INTRODUCTION

Refrigeration will be outlined a method of moving or transferring heat from one location or point to a different location or point. essentially it's an art of maintaining temp of system less than surrounding and it will be achieved by transferring heat from lower to higher temp to accomplish this work need to be supplied to the system. Work will be mechanical work, magnetism, electricity and plenty of alternative supply.

It has had an outsized impact on several industries, life, agriculture and plenty of other issue. The thought food preserving dates back to the ancient civilisation. However, refrigeration technology has quickly evolved within the last century, from ice harvest to temperature-controlled rail cars. The introduction of cold rail cars contributed to the westward enlargement of the us, permitting settlement in areas that weren't on main transport channels like rivers, harbors, or depression trails. Settlements were conjointly developing in sterile components of the country, full of new natural resources. These new settlement patterns sparked the building of enormous cities that are ready to thrive in areas that were otherwise thought to be inhospitable, like Houston, Texas and city, Nevada. In most developed countries, cities are heavily dependent upon refrigeration in supermarkets, so as to get their food for daily consumption.

the rise in food sources has led to a bigger concentration of agricultural sales returning from a smaller share of existing farms. Farms these days have a way larger output per person compared to the late 1800s. This has resulted in new food sources obtainable to entire populations, that have had an outsized impact on the nutrition of society.

1.2 Vapour compression refrigeration system-

A vapour compression cooling system uses a refrigerant sealed in an airtight and leak proof mechanism. The refrigerant is circulated through the system and it undergoes a no of changes in its state whereas passing through numerous elements of the system. every such amendment within the state of vapour is termed a method. the method of repetition of an analogous order of operation is termed a cycle.

The compression cycle is given this name as a result of it's the compression of the refrigerant by the mechanical device which allows transfer of heat energy. The refrigerant absorbs that from one place and releases it to a different place. In alternative words the mechanical device is employed to place the warmth laden refrigerant vapour in such a condition that it should dispute the heat it absorbed at low from the refrigerated area, to an simply obtainable cooling medium. It is the most commonly used refrigeration cycle.

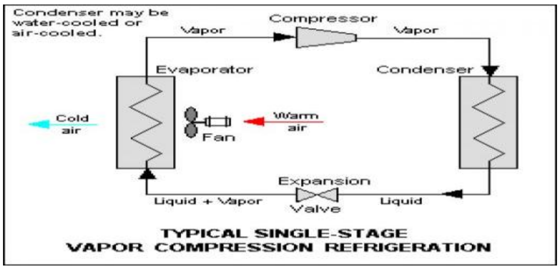

Figure 1.1 Typical Single-Stage Vapor Compression Refrigeration

II. RESEARCH OBJECTIVES AND CONTRIBUTIONS

The aim of this study is to provide a detailed insight into the characteristics of robust mechanism for preparing a new eco-friendly mixture of refrigerant as a replacement of R-134A. We proposed a new scheme which applies hybrid approach using different highly eco-friendly refrigerant mixture. The scheme is robust against existing methodology using other alternative refrigerant.

- Experiments have been done on these highly eco-friendly refrigerant mixture for vapour compression refrigeration system schemes to test and show its performance.
- We compare the proposed scheme with the existing scheme in different aspects and discuss the advantages and the disadvantages of our scheme.
- Our approach cultivates an idea of use of highly eco-friendly refrigerant mixture in place of R-134a refrigerant which applying a hybrid approach to the proposed scheme. Its advantages are clear and significant.

III. EXPERIMENTS SETUP

3.1 Performance Comparison of R134a with Alternate Refrigerant

1. **Ice Plant:** R134a has high global warming potential around 1300 as mentioned in abstract hence it needs to be phased out. The basis of replacement is to analyze the performance of existing plant working on R134a and comparing it with eco friendly refrigerant which can be possible replacement of R134a. Reading of pressure and temperature for the calculation is taken from an ice plant with vapour compression refrigeration cycle using R134a.Calculation of theoretical C.O.P is by using pressure enthalpy chart or by using REFPROP SOFTWARE at pressure and temperature condition obtained from reading.

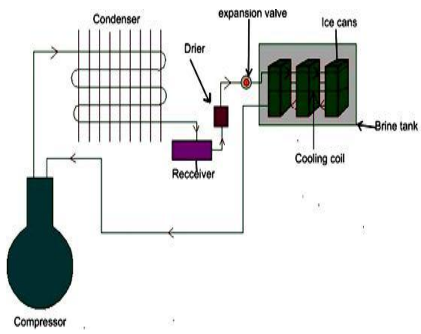

Figure 3.1 Schematic block diagram of ice plant

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Table 3.1 Pressure and temperature reading of ice candy plant

P1	P2	T1	T2	T3	T4
2	**13**	**20**	**80**	**30**	**-11**

P1= Suction Pressure of Compressor (Bar)

P2= Discharge Pressure of Compressor (Bar)

T1= Suction Temp of Compressor (°C)

T2 = Discharge Temp of Compressor (°C)

T3= Temp of Condenser exit (°C)

T4 = Temp (°C) After Expansion valve

For R134a at p1=2bar and T1= 20˚C, h_1 = 418.3 KJ/kg at p1=13bar and T1= 80˚C, h_2 = 458 KJ/Kg at p1=13bar and T1= 30˚C, h_3 = 241.7 KJ/Kg at p1=2bar and T1= -11˚C, h_4 = 185.4 KJ/Kg

COP of vcr cycle= desired effect/ work supplied

COP = $(h_1-h_4)/(h_2-h_1)$ = 5.86

Given table shows the list of refrigerant with their ozone depleting potential, global warming potential and chemical properties. It can be seen from the table that R32, R152a and R245a has GWP less than R134a, hence these three can be taken as possible replacement of R134a

Table 3.2 Hydro fluorocarbons Refrigerant Properties

Refrigerants	O.D.P	G.W.P	Chemical properties
R23	0	14800	Slightly flammable
R32	0	650	Slightly flammable
R125	0	3400	Not flammable
R134a	0	1430	Flammable
R143	0	4300	Slightly flammable
R152a	0	120	Slightly flammable
R218	0	8830	Non flammable
R245a	0	950	Non Flammable

These refrigerants are taken in different ratio by mass. COP, GWP and molecular of these mixture are calculated using REFPROP software. Below table's shows refrigerants with their respective composition by mass, also we shows their respective COP, GWP and Mol.wt.

Table 3.3 Refrigerant Properties

Refrigerants	Mol. Wt	Critical temp (°C)	GWP	ODP
R134a	102	101.06	1300	0
R32	52.02	78.11	650	0
R152a	66.05	113.26	120	0
R245a	135	174.42	950	0

Table 3.4 keeping the composition of R245a constant

R32	R152a	R245a	Cop	Mol. Wt	GWP
0.1	0.4	0.5	6.84	98.6	588
0.2	0.3	0.5	4.9	97.2	641
0.3	0.2	0.5	3.8	95.8	694
0.4	0.1	0.5	2.98	94.4	747

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R32	R152a	R245a	Cop	Mol. Wt	GWP
0.1	0.5	0.4	6.84	91.8	505
0.2	0.5	0.3	4.18	83.6	475
0.3	0.5	0.2	2	75.4	445
0.4	0.5	0.1	0.71	67.2	415

Table 3.6 keeping the composition of R32 constant

R32	R152a	R245a	Cop	Mol. Wt	GWP
0.5	0.1	0.4	1.97	86.2	717
0.5	0.2	0.3	1.38	79.4	634
0.5	0.3	0.2	0.7	72.6	551
0.5	0.4	0.1	0.7	65.8	468

From the above table it can be concluded that composition r32/r152a/r245a can be taken as possible replacement of R134a in vapour compression refrigeration cycle. Below table shows the composition and have been named as M1 and M2 respectively. Performance of M1 and M2 with R134a is analyzed on the basis of their density, enthalpy, entropy, molecular weight and global warming potential.

Table 3.7 Refrigerant taken from the tables as possible replacement

Refrigerant	R32	R152a	R245a	Mol wt	GWP
M1	0.1	0.4	0.5	98.6	588
M2	0.1	0.5	0.4	91.8	505

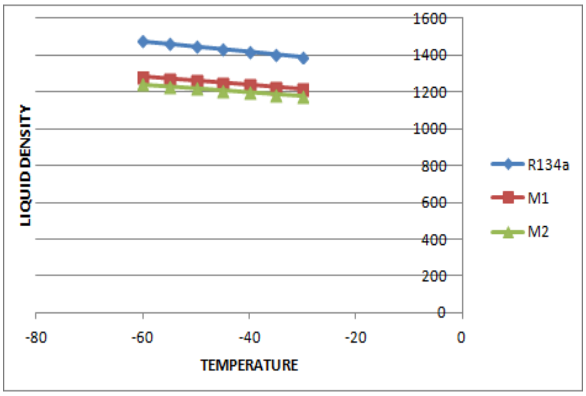

Figure 3.2 Graph liquid density vs temperature

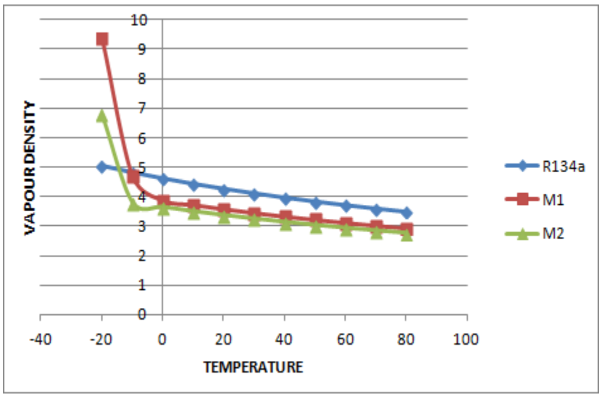

Figure 3.3 Graph vapour density vs temperature

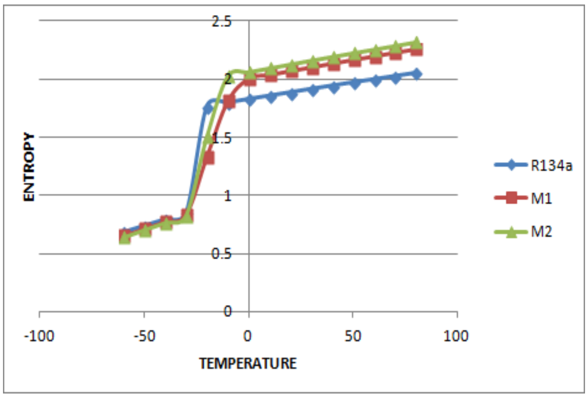

Figure 3.5 Graph show the variation in entropy with keeping constant temperature

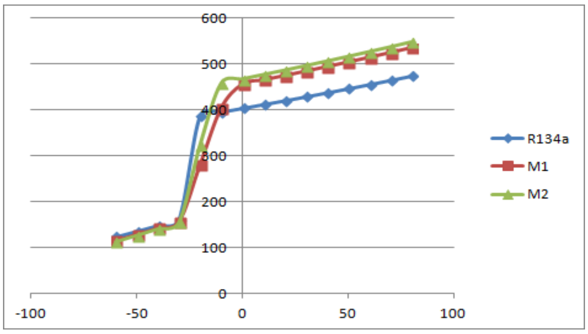

Figure 3.4 Graph show the variation in enthalpy with keeping constant temperature

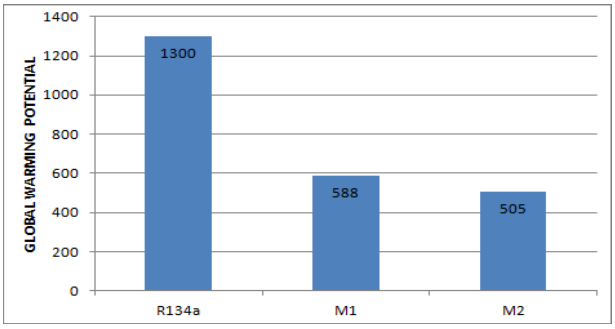

Figure 3.6 Global warming potential (GWP)

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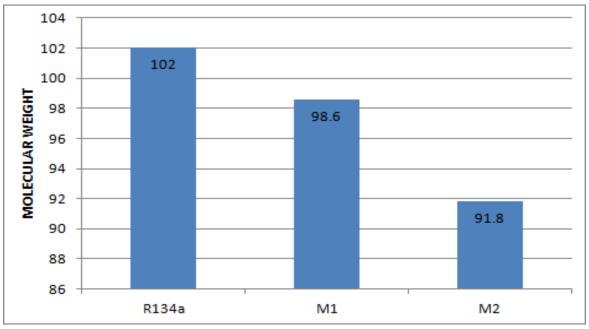

Figure 3.6 shows the molecular weight of mixture refrigerants

IV. RESULT AND DISCUSSION

Table shows of R-134a comparisons with their possible replacement M1and M2 over its COP, molecular weight, global warming potential and ozone depleting potential. R134a can be replaced with M1 and M2 since both M1 and M2 has higher cop than R134a also global warming potential le less in both M1 and M2 as compared to R134a.it can also be seen that refrigerant has zero ODP. There is not much variation in molecular weight of M1 and M2 as compared to R134a. So it can be compatible in same compressor.

Table 4.1 Result comparision of R22 with Mix 1 and Mix 2

REFRIGERENT	R134a	M1	M2
C.O.P	5.86	6.84	6.84
Molecular weight	102	98.6	91.8
Global warming potential	1300	588	505
Ozone depleting potential	0	0	0

V. CONCLUSION

Parameters	Nozzle 1 (2 mm)		Nozzle 2 (2.5 mm)	
	Max	Min	Max	Min
Velocity (m/s)	19.64	1.05	12.64	1.061
Pressure (Pa)	$1.875*10^5$	$1.34*10^4$	$7.67*10^4$	$5.482*10^3$
Turbulence K.E(m^2s^{-2})	1.619	$2.064*10^{-3}$	0.752	$2.05*10^{-3}$
Viscosity (Pa S)	$8.84*10^{-2}$	$2.76*10^{-3}$	$6.102*10^{-2}$	$2.680*10^{-3}$
Eddy Dissipation (m^2s^{-3})	$8.40*10^3$	$4.93*10^{-2}$	$2.11*10^3$	$4.82*10^{-2}$

VI. CONCLUSION

Out of the two possible replacement M1 and M2, M2 can be taken as better replacement. Both M1 and M2 has same COP but global warming potential is less for M2. Also it has high enthalpy at both liquid and vapour stage so it has higher heat extracting and releasing capacity at evaporator and condenser respectively. Also the replacement M1 and M2 are halocarbon with which is nontoxic and nonflammable. Hence M2 can be suggested as best replacement.

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