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PERFORMANCE ANALYSIS OF AIR COOLED WATER COOLER BY USING ECO-FRIENDLY REFRIGERANTS AS A POSSIBLE SUBSTITUTE OF R134A

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ABSTRACT
The EU F-gas regulation would take effect from January 1,2015. The regulation implies an HFC phase-down from 2015 to 2030 by means of bans on high GWP refrigerants. Especially R134a is under pressure and likely to be phased out of all commercial systems. Since the regulation has just been adopted andthere is still a great deal of uncertainty as to what will happen. we follow the situation closely and just like other experts we expect the use of low GWP refrigerants to grow with intermediate solutions emerging like for instance R152a as substitution for R134a; although these solutions are intermediate they are likely to be used for some years into the future. We also expect new blends of R152a and R134a to play a role yet to be seen.

In the present work, the performance of the Air cooled water cooler test rig based on vapour compression refrigeration cycle is studied by using R134a and on the basis of their experimental result , we studying the result of R152a and blending of R152a with R134a in various mass fraction with help of Refprop property software. The result are analyzed in terms of Coefficient of performance(cop) , Refrigeration capacity, compressor work , condenser capacity, specific volume, Thermal conductivity and miscibility of lubricants shows that R152a, R134a/R152a-30/70 and R134a/R152a -10/90 is possible alternate for R134a.

KEYWORDS: ODP, GWP, Cop, R152a, R134a.

INTRODUCTION
On Tuesday, September 27, 2014, two of the top three greenhouse gas emitters in the world, the United States and India, announced a plan to work together to phase out potent “super” greenhouse gases, hydrofluorocarbons(HFCs).

In a joint statement released by U.S. President Obama and Indian Prime Minister Modi, recognizing, *“the need to use the institutions and expertise of the Montreal Protocol to reduce consumption and production of HFCs, while continuing to report and account for the quantities reduced under the UNFCCC”,* the two countries *“pledged to urgently arrange a meeting of their bilateral task force on HFCs prior to the next meeting of the Montreal Protocol to discuss issues such as safety, cost, and commercial access to new or alternative technologies to replace HFCs.”*

India recently surpassed the European Union as the world’s third largest emitter of greenhouse gases, behind China and the United States. HFCs, used in air conditioning, refrigeration, and insulating foams, are hundreds to thousands of times more damaging to the climate than carbon dioxide.

Air conditioner and refrigerator use is rising dramatically in India and is likely to grow up to 20 percent per year, leading to rising energy demands and increasing HFC emissions. With this explosive growth in air conditioning and refrigeration use, India’s HFC emissions are expected to exceed those of the United States, which is currently the largest consumer of HFCs. Although more than 120 countries, including the United States, support an amendment to the Montreal Protocol to phase down HFCs, India has been one of the few countries opposed to the amendment proposal.

The Montreal Protocol, hailed as the most successful international environmental treaty, regulated ozone-depleting substances such as chlorofluorocarbons (CFCs) worldwide. Its institutions and mechanisms can easily use the very

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same process to eliminate HFCs—which were commercialized to replace CFCs in mostly the same industries. Sep 27, 2014 statement, the first formal position on HFCs taken by the new Indian government led by Modi, is the first indication that India has reduced its opposition to an amendment proposal and is willing to work to a collaborative solution at the Montreal Protocol.

EU HFC Phase down schedule

The introduction of CFCs and later on HCFCs did solve important safety problems during the first part of the last century, but environmental risks were not considered until the mid-1970s. At this stage, the severe consequences of a continued use of especially the CFCs became obvious, leading to a global phase out agreement known as the Montreal Protocol. The phase out of CFCs has been accomplished globally.

Even though old systems are still running, no new system or virgin CFC for service are allowed. The replacement was to a large extent handled by replacing CFCs with HFCs without compromising safety during installation and use. However, as we know today, the widespread use of HFCs eventually becomes a major global warming source.

For the last decade global society and the industry have discussed the opportunities to reduce the impact of direct emissions from refrigeration and air conditioning systems. The HFC refrigerants commonly used have GWP values between 100 and 20,000 – but most of refrigerants used i.e. R134a, R404A and R410

ranges between 1,500 and 4,000. The EU F-gas regulation from 2006 focused on improved service and containment; however, the regulation only showed stagnation in the HFC impact. The revised F-gas regulation introduced a phase down of HFCs measured in CO_2 equivalents. The phase down would start in January 2015 and run until 2030 reducing the availability of F-gases by 79 % in the period.
In Figure 1 shows the phase-down schedule of HFC regulated by EU.

Figure 1 ***EU HFC Phase Down Schedule***

Since 2008, it has been discussed among the parties of the multilateral Montreal Protocol to have a HFC phase down schedule. Until now no final agreement has been made.

The impact of the EU phase down is not yet known. It is likely, however, that due to the market size, the critical applications and the clarity of the regulation the new situation will lead to innovations that will affect future decisions and market moves. Since many manufactures are global, the new market conditions will lead to increased technology transfer, and already the move away from high GWP refrigerants has been kicked off.

Introduction about Refrigeration Cycle-

The Vapor Compression Refrigeration Cycle is a process that cools an enclosed space to a temperature lower than the surroundings. To accomplish this, heat must be removed from the enclosed space and dissipated into the surroundings. However, heat tends to flow from a high temperature to that of a lower temperature zone.

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During the cycle refrigerant circulates continuously through four stages. The first stage is called Evaporation where refrigerant cools the enclosed space by absorbing heat. Next is Compression stage where the pressure of the refrigerant is increased, by which the temperature is also increased above the surroundings. After that hot refrigerant is goes to the next stage, that is condensation stage where the natural direction of heat flow allows the release of energy into the surrounding air.

Finally, during the last Expansion phase, the temperature of refrigerant is lowered by the auto refrigeration effect. This cold refrigerant then begins from The Evaporation stage again and removing more heat from the enclosed space. In Figure 2 shows Schematic and T-S representation of vapour compression cycle.

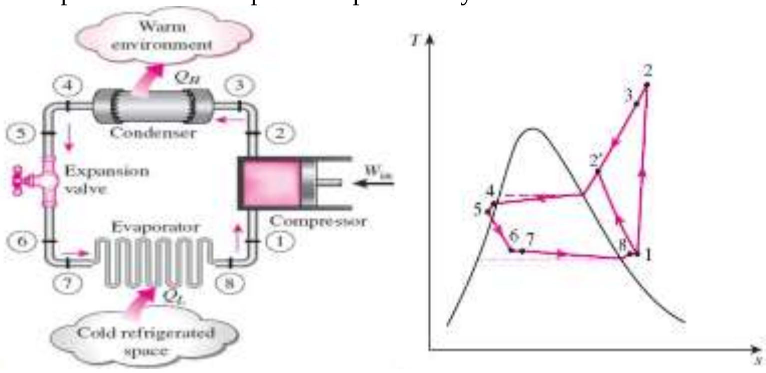

Fig 2 Schematic and T-S diagram for actual vapour compression cycle

Introduction and Specification of Testing Unit-

In figure 3 Combined Test rig unit of Water cooler, Ice plant & a/c System is shown where I have done my testing on R134a Refrigerant in air cooled water cooler system. The unit contains :

Figure 3 Experimental Refrigeration & Air Conditioning test Rig Unit

COMPRESSOR: Hermetically sealed KCJ444HAG,250-50 HZ kirloskar compressor.
CONDENSER: Air Cooled
CONTROL PANEL CONSISTING OF:

Expansion Device, Glass Tube Rotameter to measure the flow of refrigerant gas, Water Rotameter to measure the flow of water circulation, Drier, Pressure Gauges, Digital type Voltmeter/ Ammeter for Compressor & Heater, Energy meter, Main Switch, Switches & Indication Lights, High pressure cutout.

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TEMPERATURE INDICATOR: Digital temperature indicator provided with RTD sensors for various temperature applications.
VOLTAGE: Single phase 220V-50Hz.

LITERATURE REVIEW -
B.O. Bolaji et al [1] investigated experimentally the performances of three ozone friendly Hydro fluorocarbon (HFC) refrigerants CFC12, HFC152a and HFC134a refrigerant found as a drop in replacement for R134a in vapour compression system.

B.O. Bolaji et al [2] discussed the process of selecting environmental-friendly refrigerants that have zero ozone depletion potential and low global warming potential. R23 and R32 from methane derivatives and HFC152a, HFC143a, HFC134a and HFC125 from ethane derivatives are the emerging refrigerants that are nontoxic, have environmental-friendly and low flammability. These refrigerants need theoretical and experimental analysis to investigate their performance in the system.

Bukola O. Balaji et al [3] investigated the exegetic performance of R12 and its substitute (R134a and R 152a) in the domestic refrigerator. HFC152a performed better than HFC134a in terms of COP and GWP.

Bukola O. Balaji et al [4] also investigated Experimental Study Of R152a And R32 To Replace R134a In A Domestic Refrigerator.

Krauss, R., et al.[5] studied about Transport properties of 1, 1-difluoroethane (R152a) which is close to R134a.

Outcalt, Stephanie L., and Mark O. McLinden et al [6] derived A Modified Benedict–Webb–Rubin Equation of State for the Thermodynamic Properties of R152a (1, 1-difluoroethane) .

and A.S.Dalkilic, S.Wongwise [7] studied about A performance compression of vapour-compression System Using Various Alternative Refrigerants.

Selection Criteria of alternative refrigerant for replacing R134a-
The main selection criteria of alternative refrigerant for replacing R134a is their compatibility with R134a,Global warming potential, ozone depletion potential, molecular weight ,thermo physical properties like thermal conductivity, specific volume & vapour pressure.

Paper no. [1], [5] &[6] indicates that properties of R152a which is similar to R134a. For the suitable substitution of any refrigerant it must have similar vapour pressure, thermal conductivity and specific volume.

Figure no. 4,5 & 6 represents variation of Thermal conductivity, vapour pressure & specific volume for Saturation temperature from -30^{0}C to 40^{0}C of R134a, R152a and their mixture in ratio of 50/50, 30/70, 10/90.which is very close to R134a.

Apart from this molecular weight, Gwp ,cop & miscibility of oil is a major factor for selecting an alternative refrigerant. Table no. 1 represents environmental properties of refrigerants.

Table no. 1 represents environmental property of refrigerants:-

PERFORMANCE PARAMETER	REFRIGERANT				
	R134a	R152a	R134a/R152a 50/50	R134a/R152a 30/70	R134a/R152a 10/90
GWP	1300	40	720	488	256
ODP	0	0	0	0	0
Molecular Weight	102	66	58.5	67.62	77.1

R152a remained miscible in all concentrations throughout the test temperature range, an advantage over R134a, R32 & R125 over a temperature range of -500 C to 900 C. R152a is thus capable of diluting a lubricant and reducing its viscosity also facilitating oil return especially from the evaporator.

We have selected R152a and their mixture because it have good oil compatibility with R134a , zero ozone depletion potential & lower global warming potential as compare to R134a

PERFORMANCE AND ANALYSIS

STUDY PROCEDURE – For studying the performance of refrigerant R134a , R152a & their mixture in ratio of 50/50, 30/70,10/90,It is necessary to know the properties of every refrigerant & their mixture.

For calculating the properties of refrigerant R134a , we have done our testing on Air cooled water cooler test rig unit (as shown in figure no. 3). Table no. 2 & 3 represent Experimental result through test rig unit in terms of pressure, temperature , enthalpy , entropy, Mass flow rate & energy meter Reading.

On the basis of Pressure and Temperature of R134a we calculate the properties like enthalpy, entropy thermal conductivity etc. of refrigerant R152a and their mixture in ratio of R134a/R152a , 50/50, 30/70, 10/90 through Refprop property software. Table no. 4,5,6,7 &8 represents property of R152a and blending of R152a/R134 in various ratio.

A theoretical performance study on a vapour-compression refrigeration system with refrigerant of R134a ,R152a and their mixture in ratio of 50/50 , 30/70 , 10/90 were done and their results are compared with R134a as possible alternative replacements.

In the refrigeration system, the representative performance characteristics are compressor power (Wc, kW), refrigerating effect (Qe, kW) and Coefficient of Performance (COP).

The experimental analysis of water cooler is based on the following assumptions:

(i) pressure losses due to friction are considered to be negligible in pipelines
(ii) heat losses through the system components in the surrounding are negligible, and
(iii) the compression process is assumed to be isentropic.

These are the basic calculation after experimental analyses of Air cooled Water cooler Test rig unit with refrigerant R134a and there result will come in the form of Table no. 2&3.

Initial temperature of water = 28.4 (^{0}C)

Mass calculation of Water in container -

Length (I) = 32 c.m.
Width (w) = 20 c.m.
Height (h) = 5 c.m.
Vol. = 0.32*0.2*0.05 = 0.00320m^3, Mass = Vol. * Density, m = 1000*0.00320 =3.2 kg
3 container water is used therefore Total mass of water M = 9.6 kg

Table : 2 Experimental result of R134a

Suction Pressure (bar)	Discharge Pressure (bar)	Suction temperature (°C)	Discharge temperature (°C)	Condenser temperature (°C)	Expansion temperature (°C)	Dial type water Cooler temperature (°C)	Mass flow rate (kg/min)	Total consume Energy meter reading (Kwh)
P1	P2	T1	T2	T3	T4	T5	q	Q
1.372	13.72	12.70	82.30	41.4	2.1	0	0.3	0.35

Table :3 Thermophysical property of R134a

Sr. No.	Subject	Pressure (bar) P	Temperature (°C) T	Enthalpy (kj/kg) h
1	COMPRESSOR INLET	1.372	12.70	413.4
2	COMPRESSOR OUTLET	13.72	82.3	459.5
3	EXPANSION INLET	13.72	41.4	258.4
4	EXPANSION OUTLET	1.372	2.1	404.6

COP = $(h_1 - h_3)/(h_2-h_1)$
COP = (413.4-258.4)/(459.5-413.4)
COP = 3.36

If R152a is used as refrigerant then following properties were come in term of thermophysical property through Refprop software.

Table :4 Thermophysical property of R152a

Sr.no.	Temp	Pressure	Density	Enthalpy	Entropy	Quality
	[C]	[bar]	[kg/m^3]	[kj/kg]	[kj/k-kg]	[mol-mol]
1	12.70	1.372	3.948	525.5	2.268	SUPERHEATED
2	82.30	13.72	37.00	577.0	2.165	SUPERHAETED
3	41.40	13.72	857.9	274.0	1.248	SUBCOOLED
4	2.100	1.372	4.123	514.5	2.229	SUPERHEATED

COP = $(h_1-h_3)/(h_2-h_1)$
COP = 4.883

If we blend both R134a and R152a in various mass fraction then the result are given in table no. 5 to 8 in the form of Pressure, Temperature, Density, enthalpy, entropy and Quality of Refrigerant

Table :5 Thermophysical property of R134a/R152, 90/10

	Temp	Pressure	Density	Enthalpy	Entropy	Quality	Massfract.	Mass fract
	[C]	[bar]	[kg/m^3]	[kJ/kg]	[kJ/k-kg]	[mol/mol]	[R134a]	[R152a]
1	12.70	1.372	5.778	424.8	1.882	Superheated	0.9000	0.10000
2	82.30	13.72	53.83	471.3	1.846	Superheated	0.9000	0.10000
3	41.40	13.72	1105	260.0	1.201	Subcooled	0.9000	0.10000
4	2.100	1.372	6.033	415.8	1.849	Superheated	0.9000	0.10000

COP =3.544

Table 6: Thermophysical property of R134a/R152a, 50/50

	Temp	Pressure	Density	Enthalpy	Entropy	Quality	Mass fract.	Mass fract.
	[C]	[bar]	[kg/m ^3]	[kJ/-kg]	[kJ/k-kg]	[mol/mol]	[R134a]	[R152a]
1	12.70	1.372	4.793	470.0	2.054	Superheated	0.5000	0.5000
2	82.30	13.72	44.88	518.5	1.988	Superheated	0.5000	0.5000
3	41.40	13.72	976.9	266.3	1.222	Subcooled	0.5000	0.5000
4	2.100	1.372	5.005	460.1	2.019	Superheated	0.5000	0.5000

COP =4.2

Table 7: Thermophysical property of R134a/R152a, 30/70

	Temp	Pressure	Density	Enthalpy	Entropy	Quality	Mass fract.	Mass fract.
	[C]	[bar]	[kg/m^3]	[kJ/kg]	[kJ/k-kg]	[mol/mol]	[R134a]	[R152a]
1	12.70	1.372	4.651	478.0	2.085	Superheated	0.30000	0.7000
2	82.30	13.72	43.56	526.8	2.013	Superheated	0.30000	0.7000
3	41.40	13.72	957.6	267.4	1.226	Subcooled	0.30000	0.7000
4	2.100	1.372	4.857	467.9	2.049	Superheated	0.30000	0.7000

COP = 4.495

Table 8: Thermophysical property of R134a/R152, 10/90

	Temp	Pressure	Density	Enthalpy	Entropy	Quality	Mass fract.	Mass fract.
	[C]	[bar]	[kg/m^3]	[kJ/kg]	[kJ/k-kg]	[mol/mol]	[R134a]	[R152a]
1	12.70	1.372	4.093	514.5	2.225	Superheated	0.10000	0.9000
2	82.30	13.72	38.36	565.3	2.130	Superheated	0.10000	0.9000
3	41.40	13.72	879.1	272.4	1.243	Subcooled	0.10000	0.9000
4	2.100	1.372	4.274	503.7	2.187	Superheated	0.10000	0.9000

COP = 4.76

RESULT AND DISCUSSION

After comparing the performance of alternative refrigerant , It is found that these parameter either close or better than R134a. These are the following properties & performance parameter which provide a valid support in favour of R152a and their mixture as a best alternative for R134a.

1. Thermal conductivity

Figure 4.represents variation of thermal conductivity of liquid refrigerant with saturation temperature for R134a and their alternative of R152a their mixture of 50/50,30/70, 10/90. As saturation temperature increases thermal conductivity of liquid refrigerants are decreases. Increase in temperature will reduce the refrigerant viscosity and thereby reduces its thermal conductivity. R152a exhibited higher thermal conductivity than R134a. The average value of R152a is approximate 16.06% higher than R134a.

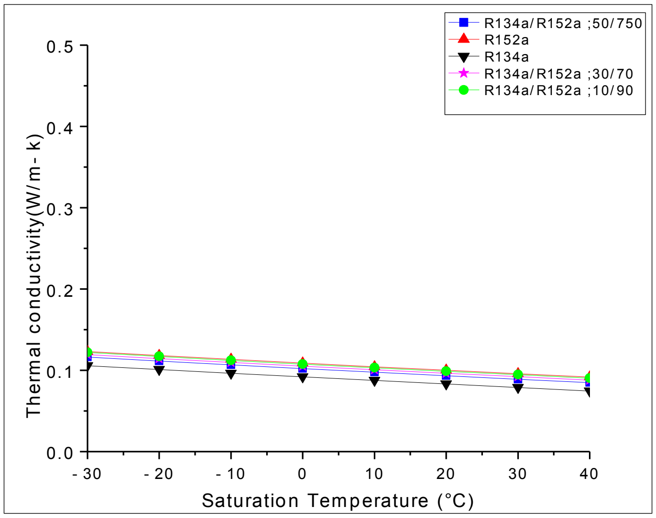

Figure 4 variation of Thermal conductivity with Saturation temperature

2. Vapour Pressure

Figure 5. shows variation of pressure with respect to saturation temperature . The P-T curve of R134, R152a and their mixture of 50/50 ,30/70, 10/90 Shown in same ways pressure increase with saturation temperature for refrigerant indicates that R152a & their mixture of 50/50 ,30/70, 10/90 exhibit similar properties and it could be used as alternate refrigerant .

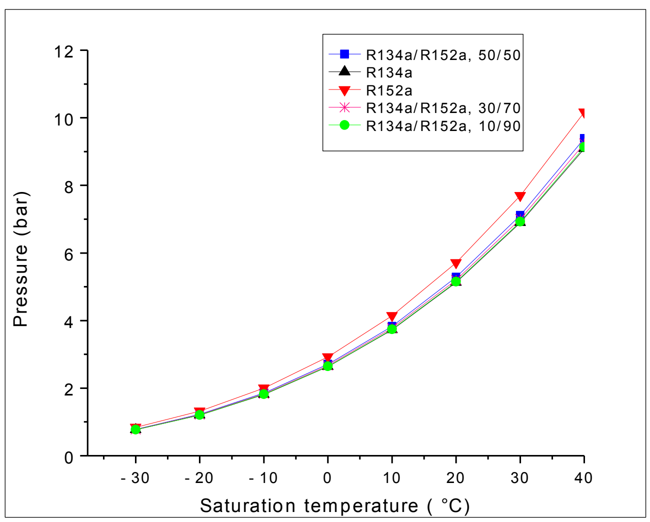

Figure 5 variation of Pressure with Saturation temperature

3. Specific Volume

Figure 6. indicates the variation of specific volume of vapour refrigerant with evaporating temp. specific volume of vapour refrigerant decreases as evaporating temp. increases .The curve between specific volume and evaporating temp.for R152a & their mixture with R134a 50/50 , 30/70 & 10/90 is very close to R134a ,It means R152a & their mixture with R134a 50/50 , 30/70 & 10/90 can works on same compressor size.

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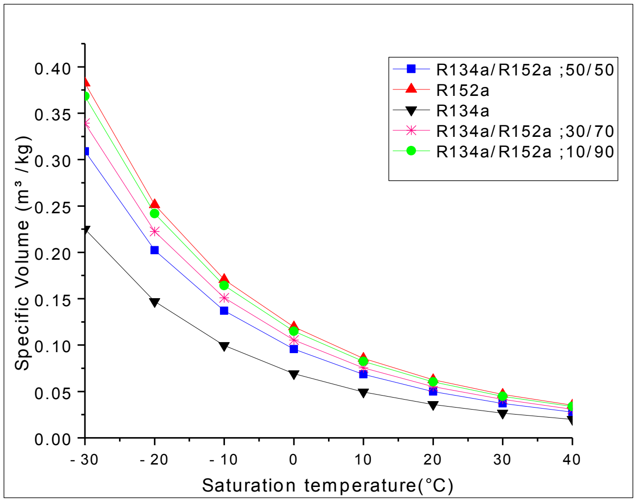

Figure 6 variation of Specific Volume with Saturation temperature

4. Global warming potential

Global warming potential is prime criterion in the selection of refrigerant, GWP of R134a and R152a are 1300 & 140 respectively.

Figure7. represents Global warming potential with mass ratio of mixture of R134a and R152a.As shown in figure increases in mass ratio of R134a will increase in GWP value but increases in R152a mass ratio will decreases in GWP . It means on the basis of GWP R152a and R134a/R152a 10-90,20-80,30-70 mixture is best alternate for R134a.

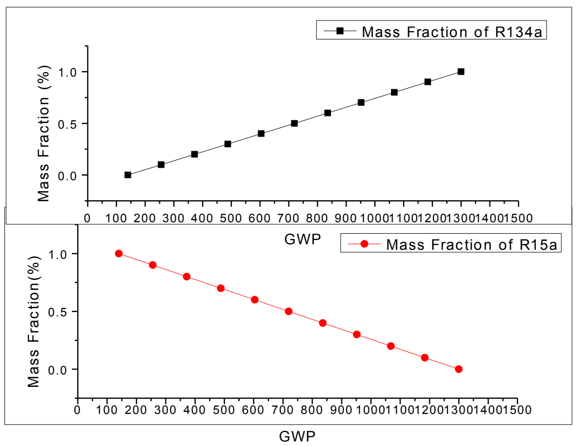

Figure 7 variation of Gwp with Mass Fraction

5. Refrigerating effect

The refrigerating effects of R134a and its various alternative refrigerants at varying evaporating temperature for the constant condensing temperature of 41.4 °C are shown in Figure (8). As shown in the figure, refrigerating effect of water cooler increases as the evaporating temperature increases for all the refrigerants. This is due to the increase in latent heat value of the refrigerant. A very high latent heat value is desirable since the mass flow rate per unit of capacity is less. When the latent value is high, the efficiency and capacity of the compressor are greatly increased. This decreases the power consumption and also reduces the compressor displacement requirements that permit the use of smaller and more compact equipment. It is clearly shown in Figure(8), that R152a and R134a/R152a mixture of 50/50, 30/70, 10/90 exhibited higher refrigerating effect than R134a. Therefore, very low mass of refrigerant will be required for the same capacity and compressor size. The refrigerating effect of R152a, R134a ,and their mixture of 50/50 , 30/70 , 10/90 in terms of average value of 239.6 ,142.4,189.48 , 208.15 , 226.51 kJ/kg respectively at the constant condensing temperature of 41.4 °C. where R152a and their mixture show higher refrigerant as compare R134a.

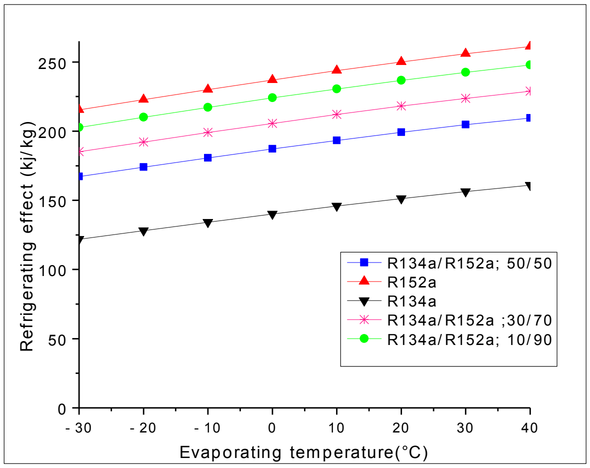

Figure 8. variation of Refrigerating effect with Evaporating temperature at condensing temperature of 41.4 °C

6. Compressor energy input

Figure 9. shows the variation of the compressor energy input with evaporating temperature for R134a and its various alternative refrigerants at constant condensing temperature of 41.4 °C. The figure describe that the compression energy input decreases as the evaporating temperature increases. This is due to increasing in the temperature of the evaporator, when evaporator temperature increases the suction temperature also increases. At high suction temperature, the vaporizing pressure is high and therefore the density of suction vapour entering in the compressor is high. Hence the mass of refrigerant circulated through the compressor per unit time increases with the increases in suction temperature for a given piston displacement. The increase in the mass of refrigerant circulated decreases the work of compression. These alternative refrigerants exhibited higher compressor energy input than R134a (Fig. 9), but they equally exhibited very high refrigerating effect (Fig. 8), which is a form of compensation for their high compressor work input.

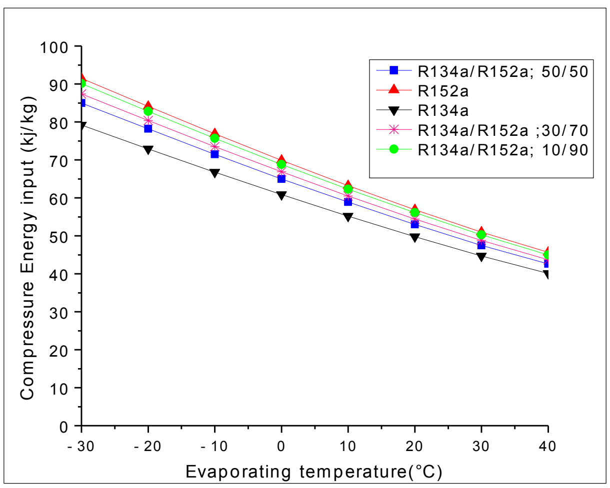

Figure 9. variation of Compressor energy input with Evaporating temperature at condensing temperature of 41.4 °C

7. Volumetric refrigeration capacity

Figure 10 shows the influence of evaporating temperature on the volumetric refrigerating capacity at condensing temperature of 41.4 °C for R134a and the alternative refrigerants. As shown in the figure, volumetric refrigerating capacity increases as the evaporator temperature increases for all the investigating refrigerants. The main reason for this , Increasing in the volume of vapour refrigerant at the exit of the evaporator. A high cooling capacity of refrigerating equipment can be obtained from a high volumetric capacity of refrigerant for given swept volume in the

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compressor. R152a & their mixture of R134a in 50/50, 30/70 , 10/90 exhibited high volumetric refrigerating capacity with average value of 9.11%, 4.77%,6.25%,6.04%, & 6.96%, higher than that of R134a.

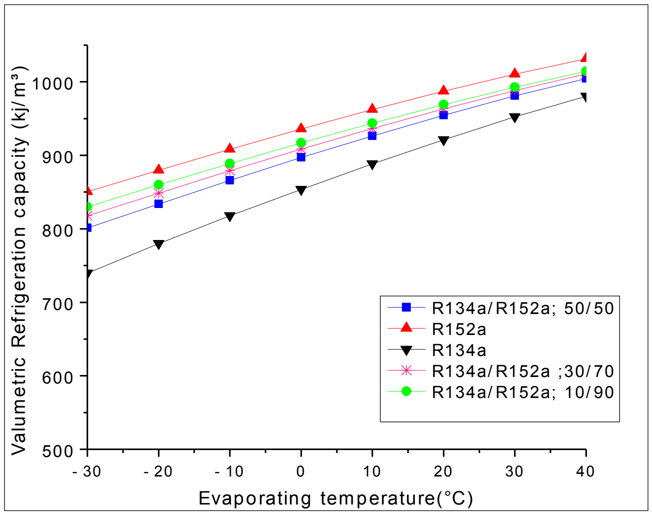

Figure 10 variation of volumetric Refrigeration capacity with Evaporating temperature at condensing temperature of 41.4 °C

8. Power per ton of Refrigeration

The influence of evaporating temperature on the power consumption per ton of refrigeration at condensing temperature of 41.4°C for R134a and other alternative refrigerants is shown in Figure 11. As shown in the figure, the power per ton of refrigeration reduces as the evaporating temperature increases for all the investigating refrigerants. In this result ,we find that R152a has emerged as the most energy efficient refrigerant among all the investigated refrigerants being the one that exhibited the lowest power consumption per ton of refrigeration with the average value of 38.7% less than that of R134a. The average value obtained their mixture in ratio of 50/50, 30/70 , 10/90 20.4%,24.82% & 29.2% lower than that of R134a, respectively.

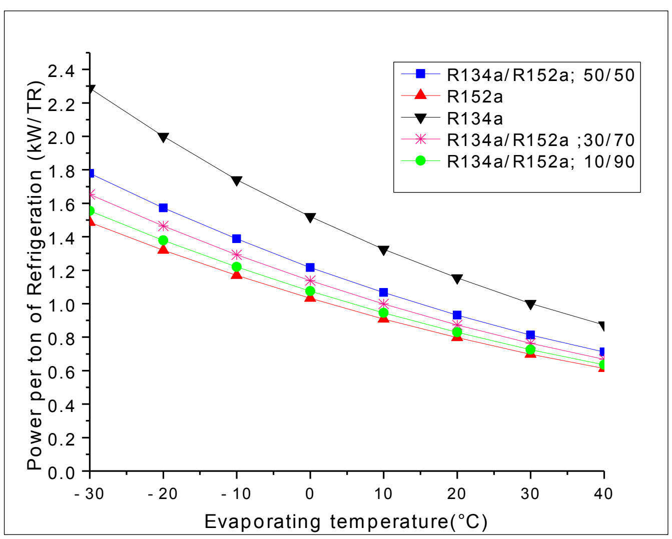

Figure 11 variation of Power per ton of Refrigeration with Evaporating temperature at condensing temperature of 41.4 °C

9. Coefficient of performance

The coefficient of performance (COP) of a refrigeration cycle reflects the cycle performance and is the major criterion for selecting a new refrigerant as a substitute. The COPs for R134a, R152a and R600a refrigerants at varying evaporator temperature for condensing temperature of 41.4 °C are shown in Figure 12. Similar trends were observed in the curve profiles for all the investigated refrigerants. COP of all refrigerant is increases with increase in evaporator temperature. As clearly shown in the figure, R134a has the lowest COP among investigated refrigerants, while R152a has the highest COP. The COPs obtained for R152a, R134a and R134a/R152a mixture of 50/50,30/70,10/90 are 2.35,1.53, 1.96, 2.11, 2.25 respectively at -30°c temp. although with increasing in temperature COPs of various alternative will increase within faster rate as compare to R134a.

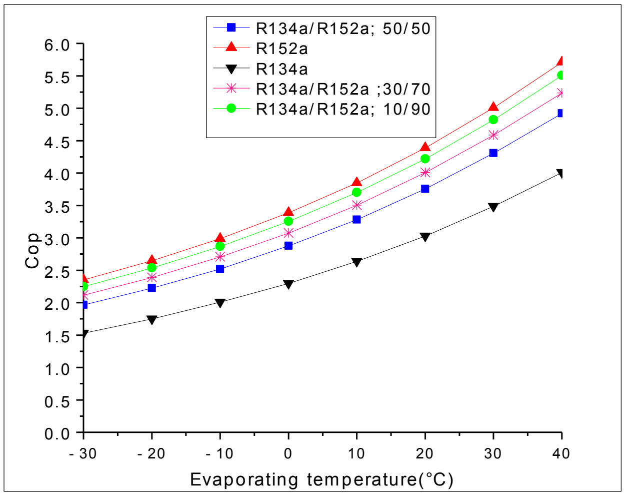

Figure 12 variation of Cop with Evaporating temperature at condensing temp. of 41.4 °C

The result shown in table no. 8 provide valid support in favour of R152a and their mixture with R134a is best alternate for R134a.

\ ***Table no. 9 represents performance parameter with various Refrigerant***

PERFORMANCE PARAMETER	REFRIGERANT				
	R134a	R152a	R134a/R152a 50/50	R134a/R152a 30/70	R134a/R152a 10/90
Refrigerating effect (kj/kg)	142.4	239.6	189.48	208.15	226.51
Compressor energy input (kj/kg)	58.7	67.4	62.7125	64.45	66.3875
Volumetric refrigeration capacity (kj/m^3)	866.77	945.8	908.20	919.18	927.10
Power per ton of Refrigeration (kw/TR)	1.47	0.9	1.17	1.105	1.104
Coefficient of performance	1.35	2.35	1.96	2.11	2.55
GWP	1300	140	720	488	256
ODP	0	0	0	0	0
Molecular Weight	102	66	58.5	67.62	77.1

CONCLUSION

The primary objective of this paper work was to study a suitable refrigerant or refrigerant mixture to replace R134a from existing domestic and small commercial refrigeration appliances with the minimum change in refrigeration system .

In this study , After discussing all parameter in varying evaporator & saturation temperature from -30^{0}C to 40^{0}C and at constant condensing temperature 41.4 ^{0}C, these are following point comes as conclusion that:-

1) Thermal conductivity of R152a & their mixture of R134a/R152a ,50/50,30/70, 10/90 is very close to R134a and R152a exhibits highest thermal conductivity that is 16.06% of R134a.
2) The saturated vapour and temperature profile of R152a & their mixture of R134a/R152a ,50/50,30/70, 10/90 is very close to vapour curve of R134a, hence R152a & their mixture of R134a/R152a,50/50,30/70, 10/90 work perfectly as alternate of R134a.
3) Suction specific volume with temperature profile for R152a & their mixture of R134a/R152a ,50/50,30/70, 10/90 is very close to R134a, It means these refrigerants work on same compressor size.Global warming potential for R134a, R152a & their mixture of R134a/R152a ,50/50,30/70, 10/90 is 1300,140,720,488 & 256 respectively, where R152a shows minimum Gwp value.
4) Ozone depletion potential for all comparative refrigerant is zero.
5) Refrigerating effect forR134a, R152a & their mixture of R134a/R152a ,50/50,30/70, 10/90 is 142.4,239.6,189.48, 208.15 &226.51respectively.where R152a shows maximum refrigerating effect.
6) Although Compressor energy input for R152a & their mixture of R134a/R152a ,50/50,30/70, 10/90 is lower than R134a but higher Refrigerating effect will compensate this.
7) Cop & volumetric refrigeration capacity for R152a & their mixture of R134a/R152a ,50/50,30/70, 10/90 is higher than R134a.where R152a have higher volumetric refrigeration capacity(945.8 kj/m^3) and cop(2.35)
8) R152a & their mixture of R134a/R152a ,50/50,30/70, 10/90 is show minimum Power per ton of Refrigeration that is0.9,1.17,1.105&1.104 (kw/TR) which is lower than R134a Power per ton of Refrigeration 1.47 kw/TR. It means R152a is best energy efficient refrigerant.

Although all the performance parameters of R152a is best but it have slightly flammable property &their mixture of R134a/R152a, 10/90,30/70,50/50 is less flammable than R152a and better performance than R134a.

Therefore R152a & their mixture of R134a/R152a ,50/50,30/70, 10/90 is best alternate for R134a as per application.

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