ANALYISIS OF VAPOUR COMPRESSION SYSTEM WITH ALTERNATIVE REFRIGERANTS

#1Shridhar Vasant Raskar, #2Sachin Vyas Mutalikdesai

[1]Mechanical Department, Savitribai Phule Pune University, Trinity College of Engineering and Research, Pune, Maharashtra, India
[2]Mechanical Department, Savitribai Phule Pune University, Trinity College of Engineering and Research, Pune, Maharashtra, India

---

Abstract: This paper investigates performance of vapour compression refrigeration system with alternative eco-friendly refrigerants R152a. In Indian domestic refrigerating market use R134a as refrigerant because of its excellent thermodynamic and thermo physical properties. Though R134a having excellent properties but GWP (1300) of this refrigerant is high. High GWP of R134a is not only problem but also it gives less efficiency. The coefficient of performance of refrigerants used in these days is decreasing. Hence it is needed to investigate the performance of alternatives refrigerants by performing different experiments which will have a low impact on the environment pollution. So performance of alternative refrigerant R152a is evaluated through evaporating pressure, pressure ratio, compression work, coefficient of performance etc in this paper. It shows that R152a will be better replacement for R134a

Keywords: Hydro -fluorocarbon, refrigerant, Vapour compression refrigeration system, COP, ODP, GWP, R134a, R152a.

---

1. Introduction

Refrigerant is one of the important organs of any refrigerant equipment. From 1930 in the overall world Chlorofluorocarbon (CFC) used as refrigerants in refrigerant system. Montreal protocol which held in 1987 phase-out the use and production of CFCs in developed country from 1996 and in developing country from 2010 (B.O. Bolaji, 2011). Three (HFC) refrigerants like R12, R152a and R134a investigated experimentally. Out of the three refrigerants, R152a shows the best desirable environmental requirements; having very low global warming potential (GWP) and zero ozone depletion potential (ODP). R32 having low coefficient of performance (COP) because of its undesirable properties such as low volumetric cooling capacity (VCC), high operating temperature and pressure and higher vapour pressure than that of R134a. COP of R32 is 37.2% higher than R134a. Refrigerants R152a and R134a, shows approximately same performance also both refrigerants shows same vapour pressure because of this R152a is considered as a good alternative for R134a. (B.O. Bolaji et al, 2011). Energy and exergy regarding refrigerants R134a, R152a, R290, R600 and R600a analyzed for computing coefficient of performance, efficiency defect, exergy efficiency, and exergy destruction ratio. It shows that COP of R152a is higher than R134a, R152a, R290, R600 and R600a also it has the highest value of exergetic efficiency among R134a, R152a, R290, R600 and R600a.Work efficiency defect is maximum in condenser and lowest in evaporator, (Gaurav, 2014) Indians domestic refrigerators use R134a as refrigerant but main problem of this refrigerants is higher GWP (1300). It is very hazardous to environment. This paper study blending of different refrigarants as alternative to R134a. According to this paper blends of R290 and R600a are the better option R134a in domestic refrigerator, because of zero ozone depletion potential (ODP) and low global worming potential (GWP) (Safvan Khansaheb, 2014). Aluminum microchannel condenser vapour compression refrigeration system use for studying experimental performance of R134a and R152a. Study shows that less amount of R152a is required as compare with R134a (V. W. Bhatkar et al, 2015) Blending of Hfo1234yf and R32 is better alternative to conventional R134a because of low GWP. This blending is very useful for mobile air-conditioners combination. Experimental analysis shows that the heat transfer coefficients of this blending were more than pure Hfo1234yf (Minxia Li, et al 2012).The thermodynamic performance and comprehensive theoretical thermodynamic cycle of R161, R22 and R290 under various operating condition were investigated. Property and thermodynamic cycle comparison showed that R161 has good thermodynamic performance than R290. The rate of cooling and heating of R161 is lower than R22 but higher than R290. COP of R161 is higher than both R22 and R290. (Yingwen Wu, et al, 2012)

Table 1 Some properties and environmental impact of selected alternative refrigerants

Refrigerants	Chemical Formula	Latent Heat Of Evaporation (Kj/Kg)	ODP	GWP	Safety Class
R134A	CH_2FCF_3	215.9	0	1300	A_1
R152A	CHF_2CH_3	301	0	140	A_2L

2. Construction and Working Principle of Vapour Compression Refrigeration System

Vapour Compression Refrigeration system is work on the principle given by Rudolf Clausius. it state that"“It is impossible for a self acting system working in a cyclic process without any external force, to transfer heat from a body at a lower temperature to a body at a higher temperature. It considers transformation of heat between two heat reservoirs. ”.This principle is popularly known as second law of thermodynamics Figure 1 shows the construction of vapour compression refrigeration system. with its components. Major component of Vapour compression system are compressor, expansion valve, condenser and evaporator.

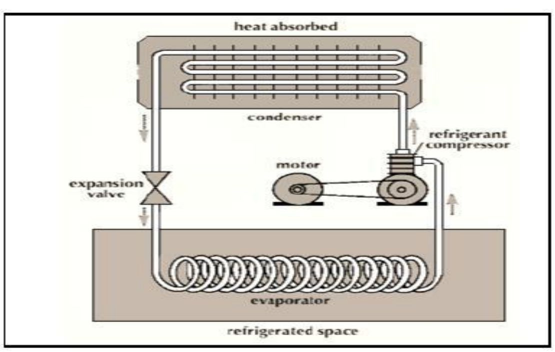


Fig.1 Vapour compression refrigeration system [8]

The refrigerant absorbed heat and cools the enclosed space during evaporation process. Pressure and temperature of refrigerant increases simultaneously and goes above the surroundings when it enters into compressor after evaporator. In condenser hot refrigerant entre from compressor and heat flow release of energy into the surrounding air. Finally, the refrigerant temperature is decreased which is called as the auto refrigeration effect when refrigerant enter into expansion phase, this cold refrigerant again enter into evaporator and start next similar cycle

T-S and P-h Diagram of VCR System

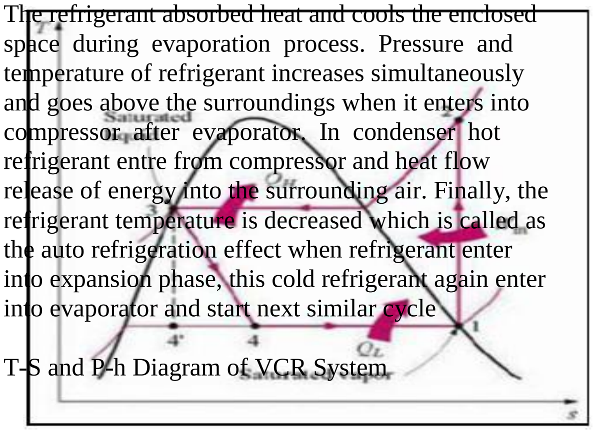


Fig.2 T-S diagram for the ideal vapor compression refrigeration system. [9]

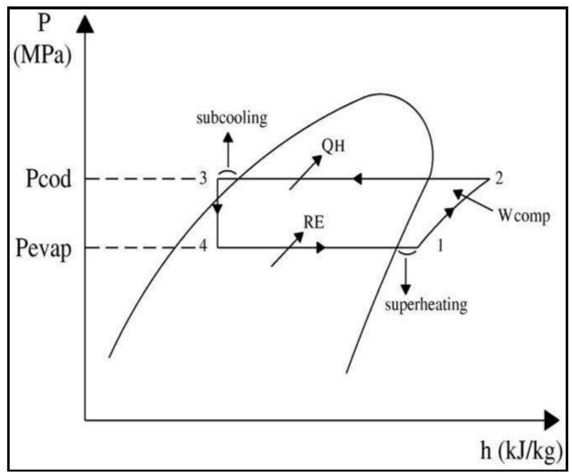


Fig.3 P-h dia. for compression refrigeration system [9]

3. Experimental setup

The main loop of vapour compression system was composed of five basic components, i.e. an evaporator, capillary tubes and a liquid line filter–drier, a condenser, a compressor as shown in Figure 4. A system of a reciprocating compressor, three-phase, 220 V, originally designed for R134a refrigerant is used. The input power which is required for compressor to work is varying between 230 and 300 W. A POE drier filter is used to absorb the moisture. For good heat transfer performances Compact forced air cooled type condenser was used. Capillary tubes of 1.269 mm of internal diameters which varies from 0.6mm to 2.5 mm were used to find the optimum operating point of the system. Shell tube type evaporator used in this evaporator tube is made up from copper material and tank is stainless steel. This stainless steel tank is superlon for minimizing theheat loss. An energy meter, 1 KW electric heater with dimmer and stirrer for controlling the evaporator temperature, an electrical switch, a voltmeter, ‘Pt100’ type thermocouples, an ampere meter, bourdon tube type low pressure gauge and high pressure gauge, indicator and gas flow control valves,these are other measuring and controlling components were used in the system.

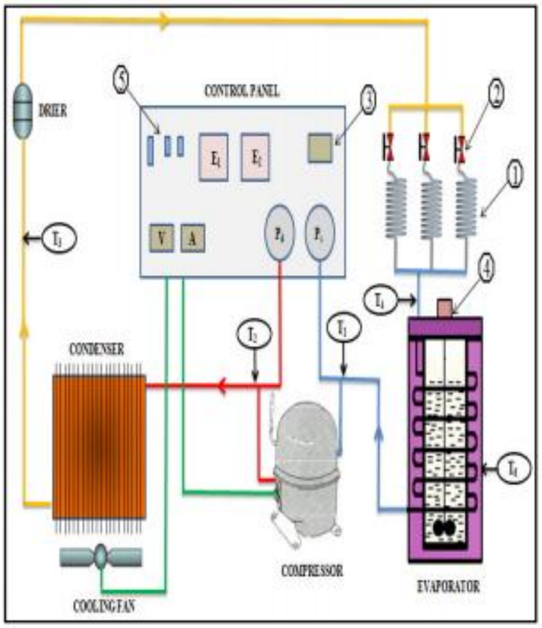


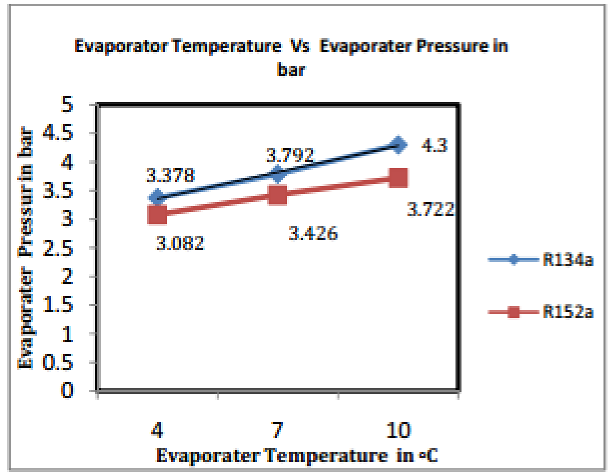
Fig.4 Experimental Setup

1	Capillary Tube	E_1	Energy Meter for Heater
2	Hand shut Off Valve	E_2	Energy Meter from Compressor
3	Temperature indicator,	P_d	Discharge Pressure
4	Stirrer Motor with Fan	P_s	Suction Pressure
5	Switches	V	Voltmeter
A	Ammeter	T_1 to T_5	Temperature Sensors

4. Results and Discussions

Evaporator Pressure

Graph1 of temperature vs. pressure shows that the variation of the saturation pressure increases with increase in the evaporator temperature for the two refrigerants. R152a shows the lower saturation pressure by 6.7 % than that of R134a. This factor is important because higher the pressure the weightier the equipment parts and accessories.

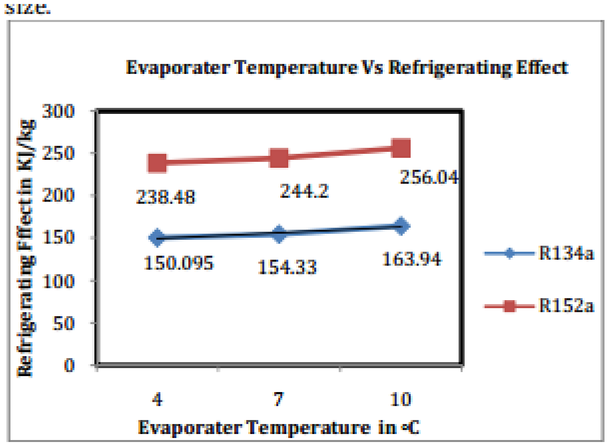


Graph.1 Variation of evaporator pressure vs. variation of evaporator temperature for R152a and R134a

Refrigerating Effect

As shown in the Graph 2, refrigerating effect increases as the evaporating temperature increases for refrigerants R134a and 152a. This happened because of increase in latent heat value of the refrigerant. Graph 2 shows that refrigerating effect of R152a higher than R134a. Therefore, very low mass of refrigerant will be required for the same capacity and compressor size.

size.

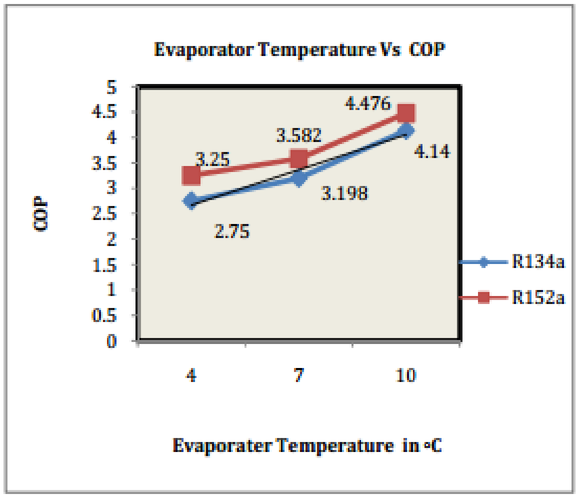


Graph .2 Variation of refrigerating effect vs. variation of evaporator temperature for R152a and R134a.

Coefficient of Performance

The coefficient of performance (COP) of a refrigeration cycle is important criteria for evaluation of cycle performance and to find out substitute refrigerant. Graph.3 shows that with increasing evaporator temperature, COP also increases. Graph.3 shows that

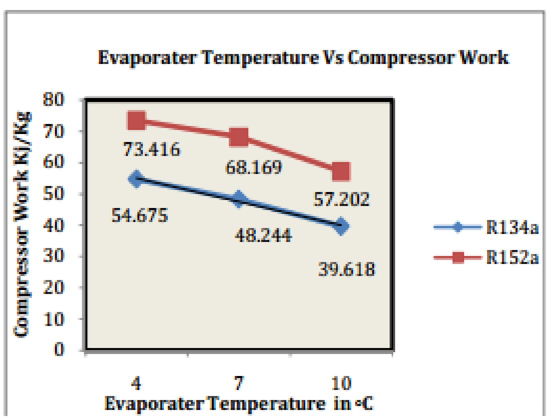
R152a has higher COP than R134a by 3.569%.



Graph.3 Variation of coefficient of performance (COP) vs. variation of evaporator temperature for R152a and R134a

Compressor Work

The variation of the compressor work with respect to evaporating temperature for R134a and R152a at condensing temperature of 51°C shown by Graph 4. The graph shows that the compression work goes down with increasing evaporating temperature



Graph.4 Variation in compressor work vs. variation of evaporating temperature for R152a and R134a.

5. Conclusion

Experimental investigation had conducted for alternative refrigerant R152a as substitute for R134a in vapour compression refrigeration system. Performance analysis was study at 51 of condensing temperature by varying evaporating temperature. We founds following conclusion

1) R152a having good properties with less impact on environment like very low Global Warming Potential (GWP) and zero Ozone Depletion Potential (ODP)
2) R152a having 3.569% higher COP than R134a
3) Other performance of R152a is approximately similar to R134a. So it is good alternative to conventional refrigerant

Reference

Bolaji.B.O. (2011) Selection of environment-friendly refrigerants and the current alternatives in vapour compression refrigeration systems, Journal of Science and Management, Vol 1, No. 1

Bolaji.B.O. Akintunde.M.A. Falade, (2011) Comparative analysis of performance of three ozone-friends HFC refrigerants in a vapour compression refrigerator, Journal of Sustainable Energy and Environment

Gaurav, Kumar Raj, (2014) Performance Analysis of Household Refrigerator with Alternate Refrigerants International Journal of Innovative Research in Science, Engineering and Technology, ISSN: 2319-8753

Khansaheb Safvan, Dr. Kapadia R.G, (2014) A Review on Domestic Refrigerator Using Hydrocarbons as Alternative Refrigerants to R134a International Journal of Innovative Research in Science, Engineering and Technology, ISSN(Online) : 2319 - 8753

Bhatkar V. W., Kriplani V. M., Awari G. K. (2015) Experimental Performance of R134a and R152a Using Micro channel Condenser Journal of Thermal Engineering Yildiz Technical University Press, Istanbul, Turkey vol.1, Special Issue 2, No. 7, pp. 575-582

Li. Minxia, Dang Chaobin, and EijiHihara, (2012) Flow boiling heat transfer of HFO1234yf and R32 refrigerant mixtures in a smooth horizontal tube: Part I. Experimental investigation, International Journal of Heat and Mass Transfer 55, pp. 3437–3446

Baskaran.A, Koshy.P Mathews, (2012) A Performance Comparison of Vapour Compression Refrigeration System Using Eco Friendly Refrigerants of Low Global Warming Potential, International Journal of Scientific and Research Publications, ISSN 2250-3153

Verma Jitendra Kumar, Satsangi Ankit, Chaturani Vishal (2013) A Review of Alternative to R134a (CH3CH2F) Refrigerant International Journal of Emerging Technology and Advanced Engineering, ISSN 2250-2459, ISO 9001:2008

Chavhan Sandip P, Mahajan S. D (2013), A Review of an Alternative to R134a Refrigerant in Domestic Refrigerator, International Journal of Emerging Technology and Advanced Engineering ,ISSN 2250-2459, ISO 9001:2008

Cabello.R, Torrella.E, Navarro-Esbri.J, (2004), Experimental evaluation of a vapour compression plant performance using R134a, RR407C and R22 as working fluids, Applied Therma Engineering 24, 1905-1917

Calm James M., (2002) Emissions and environmental impacts from air-conditioning and refrigeration systems, International Journal of Refrigeration 25, pp. 293–305