International Journal of Technical Innovation in Modern Engineering & Science (IJTIMES),(UGC APPROVED)
Impact Factor: 5.22 (SJIF-2017),e-ISSN:2455-2585
National Conference on
Recent Trends in Mechanical Engineering (NCRTIME2K19)
Volume 5, Special Issue 07, June-2019.

Performance Analysis of Vapour Compression Refrigeration System under alternative Refrigerant

Mr. Rahamath Basha Shaik [1], Mr. K. Jayaram [2], Mr. M. vinod [3], Mr. D. Anil [4], Mr. T. Hemanth Kumar [5]
1Assistant professor, Department of Mechanical Engineering, Audi Sankara College of Engineering, Gudur,A.P,
2,3,4,5 UG Scholars, Department of Mechanical Engineering, Geethanjali Institute of Science &Technology, Nellore, AP

Abstract— ***The vapor compression cycle is used in most house hold refrigeration as well as in many large Commercial and Industrial refrigeration systems. The main components in this system are compressor, condenser, evaporator and expansion valve. It uses a circulating liquid refrigerant as medium which absorbs and removes the heat from the space to be cooled and subsequently rejects the heat to atmosphere. When the use of R134a in Vapor Compression Refrigeration systems, it causes has high Global Warming Potential to Ozone layer. In this work to overcome above difficulties and to enhance the performance, the existed vapour compression refrigeration system is modified and replaced the new refrigerant instead of R134a and different quality tests are conducted to fix leakages then after completion of fabrication, the experiments are to be conducted at load and unload conditions and COP has been calculated and compared. Finally overall performance has proved that the R600a refrigerant has high COP than the R134a.***

Keywords— Vapour Compression Refrigeration System, Alternative refrigerants, R134a, R600a, Cooling, Capillary, Coefficient of Performance.

I. INTRODUCTION

Refrigeration is widely used in many areas due to critical temperatures and vast variations in atmospheric conditions. Refrigeration is the process of extract the heat from medium under controlled conditions. It also includes continuous removal of heat from the body whose temperature is already below the temperature of surroundings.R134a is the most widely used refrigerant in domestic refrigerators due to its excellent thermodynamic and thermo-physical properties but it must be phase out soon under Kyoto protocol due to its high global warming potential (GWP). Hence in order to meet the global ecological goals, conventional refrigerants must be replaced by more environment friendly and energy efficient refrigerants.

Refrigeration system consists of several equivalents like Compressor, Condenser, Expansion devices, Evaporator etc. A refrigerant compressor is a machine used to compress the refrigerant from the evaporator and to rise its pressure so that the corresponding temperature is higher than that of the cooling medium. The condenser is an important device used in the high pressure side of a refrigeration system. Its function is to remove heat of the hot vapour refrigerant discharged from the compressor. The evaporator is used in the low pressure side of a refrigeration system. The liquid refrigerant from the expansion device enters into the evaporator where it boils and changes into vapour. The function of an evaporator is to absorb heat from the surrounding location or medium which is to be cooled, by means of a refrigerant. The temperature of the boiling refrigerant in the evaporator must always be less than that of the surrounding medium, so that the heat flows to the refrigerant. The expansion device which is also known as throttling device, divides the high pressure side and the low pressure side of a refrigeration system. It is connected between the receiver and the evaporator. Many efforts have to be done to improve the performance of vapour compression refrigeration system. The properties of R134a and R600a are shown in Table 1.

TABLE 1: THE PROPERTIES OF R134A AND R600A

Refrigerant	Mol. Wt. g/mol	N B P °C	C.T ° C	C.P Mpa	Safety	O D P	G W P
R134a	102.0	-26	101.1	4.06	Non-flammable	0	1430
R600a	58.1	-12	134.7	3.64	Flammable	0	<20

II. LITERATURE REVIEW

[1] Moo-Yeon lee et. a1 - have studied the performance of a small capacity directly cooled refrigerator by using the alternative to R-134a.The compressor displacement volume of the alternative system with R600a/R290 (45/55) has modified from that of the original system with R-134a to the optimized R600a/R290 system was approximately 50% of that of the optimized R-134a system. The capillary tube lengths for each evaporator in the optimized R600a/R290 system were 500mm longer than those in the optimized R-134a system. The power consumption of the optimized R-134a system was 12.3% higher than that of the optimized R600a/R290 system. The cooling speed of the optimized R600a/R290 (45/55) system at evaporator 0C was improved temperature by 28.8% over that of the optimized R-134a system.

[2] Mihail-Dan &N. Staicovici Are investigates A method of improving the effectiveness of a mechanical vapors compression process and of its applications in refrigeration. It was shown that method can be improved of a poly-trophic or an adiabatic mechanical vapors compression system.

[3] NeerajaUpadhyay- developed a new configuration of the diffuser and sub-cooling in vapour compression refrigeration cycle, for sub-cooling a fan is used. By using diffuser power consumption is less for same refrigeration effect so performance is improved. The size of the condenser can also be reduced due to more heat transfer. So cost of the condenser will be reduced. The parameters like pressure and temperature were measured. After result analysis, we have found that the COP was enhanced from2.65 to 3.38 in the case when conventional Vapour Compression Refrigeration System was used with Diffuser.

[4] According to manual of company danfoss practical applications of Refrigerant R600a isobutene in Domestic Refrigeration System is observed by R600a, or isobutene, is a possible replacement for other refrigerants, which have high impact on environment, in domestic refrigerators. It has zero ozone depletion potential ODP and a negligible global warming potential GWP.

[5]Amitnarwal, SarveshKumar, RishabhVerma, Ravi Kumar improved coefficient of performance of system. To improve the coefficient of performance, it should be noted that compressor work should decrease and refrigerating effect should increase. Modifications in condenser are meant to increase degree of sub- cooling of refrigerant which increased refrigerating effect or more cooling water is required in condenser. The purpose of a compressor in vapour compression system is to elevate the pressure of the refrigerant, but refrigerant leaves the compressor with comparatively high velocity which may cause splashing of liquid refrigerant in the condenser tube, liquid hump and damage to condenser by erosion. It is needed to convert this kinetic energy to pressure energy by using diffuser. By using diffuser power consumption is less for same refrigerating effect so performance is improved.

III. DESIGN AND EXPERIMENTAL SET UP

In this experimental set up is designed to find the COP of the domestic vapour compression system. The vapour compression uses a circulating liquid refrigerant as the medium which absorbs and removes heat from the space to be cooled and subsequently rejects that heat into atmosphere. Figure 1 depicts a typical, single -stage vapour compression system. All such systems have four components: a compressor, a condenser, a thermal expansion valve (also called a throttle valve or metering device), and an evaporator. Circulating refrigerant enters the compressor in the thermodynamic state known as a saturated vapour and is compressed to a higher pressure, resulting in a higher temperature as well. The hot , compressed vapour is then in the thermodynamic state known as a superheated vapour and it is at a temperature and pressure at which it can be condensed with either cooling water or cooling air. That hot vapour is routed through a condenser where it is cooled and condensed into a liquid by flowing through a coil or tubes with cool water or cool air flowing across the coil or tube. This is where the circulating refrigerant rejects heat from the system and the rejected heat is carried away by either the water or the air.

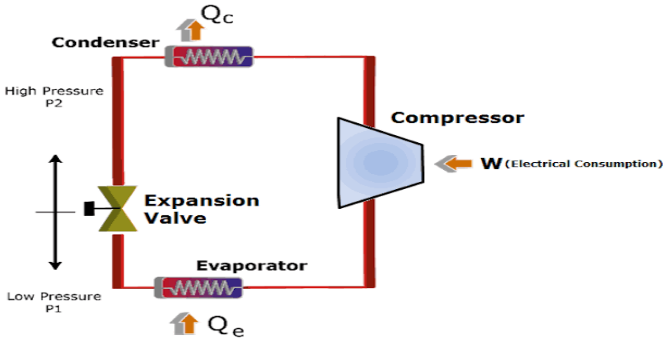


Fig 3.1: Line diagram of VCR system

Fig 3.2: vapour compression refrigeration system

The experimental set up consists of following components.

1) Compressor.

2) Condenser, air cooled.

3) The expansion device (capillary tube).

4) The evaporator.

5) Pressure gauges are fitted at suction and discharge of the compressor.

6) Thermo-couples are measured by temperature at various points.

IV. EXPERIMENTAL PROCEDURE

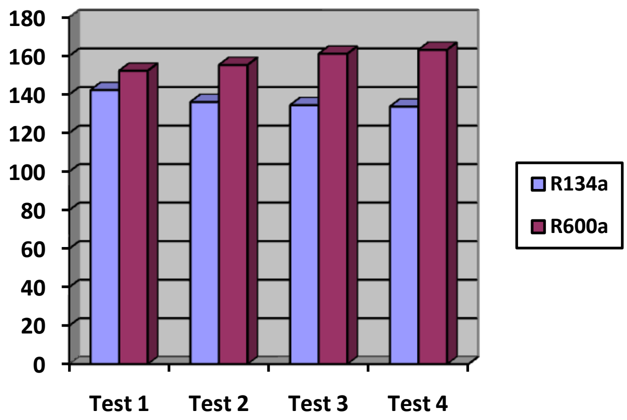
A Domestic Refrigerator is selected for this experiment. While coming comparing two types of refrigerant using the refrigerator is R134a & R600a at constant evaporator temperature. The domestic refrigerator works on vapour compression refrigeration system. The Compressor usually sealed. In this system the thermostat is disconnected because compressor is working continue. The process is comprises of a compressor, condenser, expansion and Evaporator. The Vapour Compression Refrigeration System using condenser at compressor outlet and expansion valve at outlet of condenser. Capillary is fitted at end of expansion valve. The pressure gauges are fitted one at discharge of compressor and another at condenser outlet. And also thermo-couples are fitted for various temperature measurements i.e. at compressor outlet, at condenser outlet, at evaporator.

The vapour compression refrigeration system is started first with R134a observations are noted like suction and discharge pressures, various temperature readings. Energy performance calculations are done like refrigeration effect, compressor work, COP. Similarly the refrigerant R600a also be tested with existing system. Finally the existing system of both refrigerants performance values are listed below table 2.

V. RESULTS AND DISCUSSION

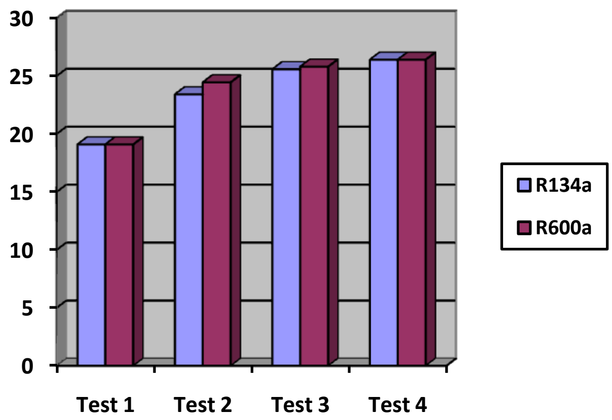
BY PERFORMING THIS EXPERIMENT THE FOLLOWING RESULTS WERE OBTAINED.

Refrigerant	**Temp. °c**	**Refrigeration Effect KJ/Kg**	**Work done KJ/Kg**	**COP**
R134a	10.3	133.65	26.4	5.06
R600a	10	163.13	26.4	6.17



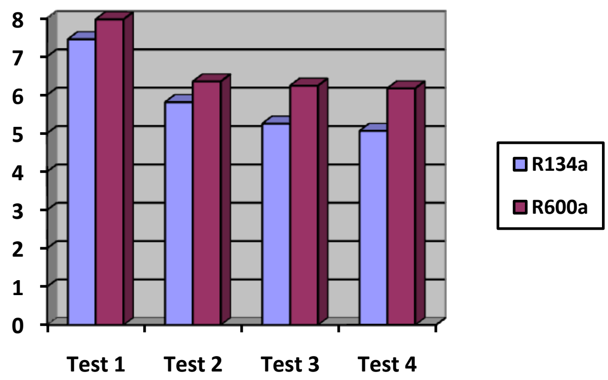
Graph: Refrigeration effect comparison of R134a &R600a

The above graph shows that refrigeration effect of the both systems compared the refrigerants is R134a &R600a. Refrigeration effect is on y-axis.



Graph: Work done comparison of R134a &R600a

The above graph shows that Work done comparison of the both systems the refrigerants are R134a &R600a. Work done is on y-axis.



Graph: COP comparison of R134a & R600a

The above graph shows that COP comparison of the both systems the refrigerants are R134a &R600a. COP is on y-axis.

VI. CONCLUSION

The performance of a domestic refrigerator originally designed for R134a was investigated using R600a refrigerant.

R-134a

The use of R134a in vapour compression refrigeration system the COP value is 5.06, work done by the compressor in the VCR system is 26.4 KJ/Kg and refrigeration effect is 133.65 KJ/Kg.

R-600a

The use of R600a in vapour compression refrigeration system the COP value is 6.17, work done by the compressor in the VCR system is 26.4 KJ/Kg and refrigeration effect is 163.13 KJ/Kg.

The COP of the modified system increases by 11.1% with optimized charge of R600a than the original system with R134a refrigerant. This comparison is taken at 10 °C.

VII. SCOPE FOR FUTURE WORK

- The work can be done by using the different type of fast free domestic refrigerator.
- Attempts can be made to reduce GWP with the same setup.
- From the review of the literature, R134a is the leading refrigerant in India which is used to substitute R12 due to its high ODP value. Even though R134a is a non-toxic, non-flammable and has a zero ODP, it is one of the green house gases. It is seen that most of the available alternative refrigerants are not matching with the R134a in various aspects such as saturation properties, energy efficiency and safety. On the other hand R600a has better energy efficiency but is in flammable issues, which restrict usage in existed systems. It is possible to mix hydrocarbon refrigerants with other alternatives such as HFC refrigerants. The GWP of HFC/HC mixtures is less than one third of HFC, when it is used alone.

REFERENCES

[1] Mihail-Dan & N. Staicovici, International journal of Heat and Mass Transfer, Are investigates “A method of improving the effectiveness of a mechanical vapour compression process and of its applications in refrigeration” 3 August 2010.

[2] Moo-Yeon Lee, “The performance of a small capacity directly cooled refrigerator by using the mixture of R600a/R290 mass fraction of 45.55 as an alternative to R134a”, International Journal of Refrigeration-June 2008.

[3] NeerajaUpodhya, “To study the effect of Sub-cooling and Diffuser on the COP of Vapour Compression Refrigeration System”, International Journal of Research in Aeronautical and Mechanical Engineering ISSN:2321-3051 June 2014.

[4] P.L.Ballany, “Refrigeration and Air Conditioning” khana publishers, 2004.

[5] S.C Arora, and Domukundawar, “Refrigeration and Air Conditioning”, Dhanpatrai sons publications Co.Ltd.,2000.

[6] R.S. Khurmi, G.K Gupta S.Chand, “A Text book of Refrigeration And Air Conditioning”, 2006.

[7] Yetti Siva, Dr.Smt.G.Prasanthi, “Performance Analysis of Eco-friendly HC Mixture (R290/R600a) Refrigerant as an Alternative to R134a in a Vapour Compression Refrigeration System for sub-Cooling using Heat Exchanger at Condenser Outlet and Diffuser at Condenser Inlet”, ISSN: 2348-7968 December 2015.