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Experimental Performance on VCR Cycle by using Eco-Friendly Refrigerant (Mixture of R134a & R600a): A Review

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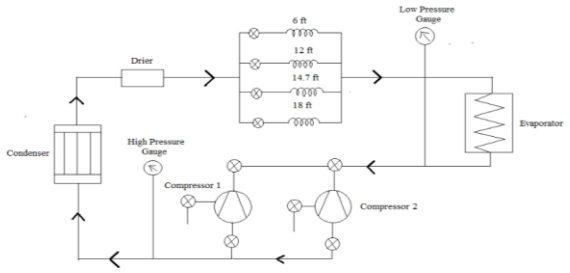
***Abstract*— Refrigerator is a household appliance used to preserve the foods, vegetables, beverages at low temperature. Refrigerant is the blood of the refrigerator and it changes its phase to transfer heat for giving cooling effect inside the refrigerator. Normally many refrigerator works under the vapor compression cycle and it uses only one refrigerant. A refrigerant mixture with low global warming potential and ozone depletion potential is proposed as drop-in replacement of most commonly used refrigerant R134a.**

In this project combination of R600a (isobutane) and R134a (1, 1, 1, 2-tetrafluroethane) is selected as a mixed refrigerant. R600a have some good properties like zero ODP, zero GWP and high latent heat of vaporization and R134a is non-toxic, non-flammable, non-corrosive and zero ODP.

***Keywords*—Domestic refrigerator, R134a and R600a**

I. INTRODUCTION

The basic purpose of refrigeration is to remove heat from a particular place. Refrigeration is a process of removing heat from a closed medium and rejected into the ambient medium. Refrigeration has many applications, from which one of the important applications is domestic refrigerators. First, it absorbs the large amount of thermal energy required to change a liquid to a vapour so we can easily remove the heat out of our refrigeration space. Second, the isothermal nature of the vaporization allows extraction of heat without raising the temperature of the working fluid to the temperature of whatever is being cooled. Vapour compression refrigeration cycle in which the refrigerant undergoes phase changes, is one of the many refrigeration cycles and is the most widely used method for air-conditioning of buildings and automobiles, domestic and commercial refrigerators, large-scale warehouses for chilled or frozen storage of foods and meats. All vapour compression refrigeration systems consist of four basic components along with the interconnecting piping. These are the evaporator, condenser, compressor and the expansion valve.



II. REFRIGERANT

Refrigerants are those fluids, which are used as fluids, for example in vapour compression refrigeration systems. Now a days in India we use R134a refrigerant in domestic refrigerator due to its excellent thermodynamic and thermo physical properties. R134a is a hydrofluorocarbon that has zero ozone depletion potential and a little global warming potential is about 1300. Its chemical formula is CF3CH2F. R134a has some good properties they are non-flammable, non-explosive, good chemical stability and toxicity within limits. The refrigeration effect of R134a is 22% more than the R12 refrigerant. The mass flow rate of R134a is 18% less than R12. The power requirement for producing ton of refrigeration is also less than other refrigerants. R600a (isobutene or i-butane) also known as methyl propane. Its chemical formula is C4 H10 and is an isomer of butane. The reason behind for choosing R600a is in the project, it is doorless and colourless gas. The ozone depletion potential for R600a is zero and the global warming potential is very low. Now the fourth-generation refrigerants focus on the global warming potential, ozone depletion potential, non-flammable, nontoxic, efficient and good stability. The R600a refrigerant is long term alternative for chlorofluorocarbons, hydro fluorocarbons and hydro chlorofluorocarbons.

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Because it will increase the system performance, the energy efficiency and environmental impacts. The latent heat of vaporization for R600a is high so it will give large amount of refrigeration effect. But R600a has one disadvantage that is flammability. The explosive limits of R600a (iso butane) are 1.4 – 8.3%. If we use R600a refrigerant within 100gms, it should not a flammable one. In this project, we take 60% of R600a and 40% of R134a for increase coefficient of the performance of the system. These two refrigerants are easily available and cheap and also has better thermodynamic and thermo physical properties.

Refrigerant	Chemical Name	Chemical Formula	GWP	ODP	Boiling point at Atm pressure (°F)	Freezing point at Atm pressure (°F)
R-134a	1,1,1,2-tetrafluoroethane	CH 2FCF 3	1430	0	-15.1	-141.9
R-600a	isobutane	CH(CH 3) 2CH 3 A3	3	0	10.8	-229

Physical properties of selected refrigerant

III. COMPONENTS

The Components of Vapour Compression Refrigeration System are:

A. *Compressor:* The semi hermetic single cylinder reciprocating compressor used in this vapour compression refrigeration system. It sucks the low temperature and low-pressure refrigerants and delivers it as high pressure and high temperature refrigerants. It has many parts such as piston, cylinder, inlet valve, exit valve, connecting rod, crank, piston pin, crank pin and crankshaft. Finally, the low-pressure saturated vapour is compressed to a high pressure superheated vapour in isentropic process.

B. *Condenser:* It is one of the major operating components in domestic refrigerator which is used to remove the heat from the high temperature and high-pressure refrigerant. In domestic refrigerator we used air cooled type condenser for remove the heat from the refrigerant. Finally, the high pressure superheated vapour is sub-cooled saturated vapour state and then condenses into a saturated liquid state under constant pressure process.

C. *Expansion valve*: Another basic component of the vapour compression refrigeration system is expansion device. The basic functions of expansion valve are to reduce the pressure from condenser pressure to evaporator pressure and regulate the flow of the refrigerant. The several types of expansion devices are hand expansion valve, capillary tubes, automatic expansion valve, thermostatic expansion valve, float type expansion valve and electronic expansion valve. In domestic refrigerators we use capillary tubes. With the use of capillary tube, the high-pressure saturated liquid is expanded to a low pressure and temperature liquid-vapour mixture at constant enthalpy.

D. *Evaporator:* The process of heat removal from refrigerated space is done by evaporator with the use of refrigerant. If the latent heat of vaporization of the refrigerant is high, the refrigeration effect would be high. Because the high latent heat of vaporization refrigerants will absorb more amount of heat while it transfers from liquid to vapour. Finally, the low-pressure two-phase mixture boils to saturated vapour under constant pressure.

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IV. Experimental Setup And Methodology

The refrigerator used in this experiment was designed by whirlpool and the capacity of the refrigerant is 175 litres. The type of compressor used in this refrigerator is single cylinder reciprocating type and this refrigerator has a five-star rating for energy consumption. The mixed refrigerants (R134a & R600a) used in this refrigerator is the proportion of 60:40. The refrigerator is placed in a room where the refrigerator is exposed to atmospheric temperature and pressure. The refrigerants used are R600a and R134a are mixed together in the single cylinder reciprocating compressor.once the required quantity of refrigerant A is filled in then the refrigerant B is feed by the same process . In our project we selected 75g of R600a and 50g of R134a. Since both the refrigerants are chemically inert they wont react with each other . Once the refrigeration is stable the temperature can be observed for calculation.

V. Scope

1. The temperature at the evaporator can be easily controlled by regulating expansion valve.
2. Capability of removing large quantities of heat with a small mass flow of refrigerant.
3. High efficiency, arguably one of the most efficient refrigeration systems at the macroscale, producing high COP
4. Latent heat involved in phase change ensures high value of heat removal, while air refrigeration system has sensible heat only

VI. Features

1. A horizontal or vertical pressure vessel, equipped internally with a demister, between the evaporator and the compressor inlet to capture and remove any residual, entrained liquid in the refrigerant vapor because liquid may damage the compressor.
2. Large commercial or industrial refrigeration systems may have multiple expansion valves and multiple evaporators in order to refrigerate multiple enclosed spaces or rooms. In such systems, the condensed liquid refrigerant may be routed into a pressure vessel, called a receiver, from which liquid refrigerant is withdrawn and routed through multiple pipelines to the multiple expansion valves and evaporators.
3. Filter Dryers, installed before the compressors to catch any moisture or contaminants in the system and thus protect the compressors from internal damage
4. Some refrigeration units may have multiple stages which requires the use of multiple compressors in various arrangements.

VII. Conclusion

The enhancement of COP can be done by using the mixture of the refrigerants R134a & R600a for lowering the GWP and ODP.

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