Comparative Analysis of Refrigerator Using Refrigerant R-134a & R-600a Fitted With Water Cooled Condenser

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***Abstract*- This comparative analysis is carried out to clarify the performance of refrigerator connected with water cooled condenser using R-134a and R-600a refrigerant. The refrigerator uses the vapor compression cycle in its process. Its performance is the major criteria. As there are many researches still under way to find out the improved efficiency of the system. This article presents the effect of the water cooled condenser in the COP of the domestic refrigerator. The aim of this article is to compare the COP of the refrigerator using R-134a and R-600a refrigerant connected with water cooled condenser. This experiment is conducted in a domestic refrigerator (Godrej Classic) of 165 liters of capacity assembled with a test platform. In this study an innovative water cooled condenser for residential refrigerator was introduced. In this experiment it is observed that the COP is increased by 34.71% using R-600a refrigerant. The thermal properties at different points in the refrigeration cycle were measured for typical operating conditions for both the refrigerant.**

Index Terms- Compressive Sensing, Data Gathering, Random Walk, Wireless Sensor Network Water Cooled Condenser, R-134a, R-600a

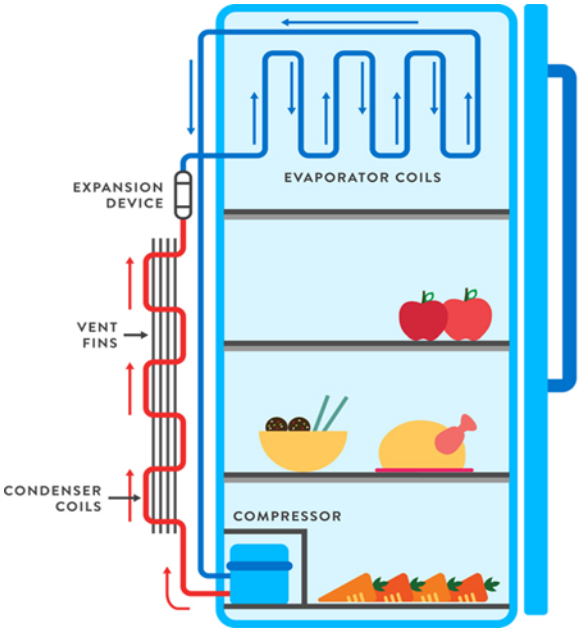
I. INTRODUCTION

Refrigeration is a process used to abstract heat from a body of lower temperature and releases it to higher temperature (atmosphere). It is generally used to take care of perishable goods. Refrigerator is used as a house hold appliance. At present Vapor Compression Refrigeration Process is used.

The basic elements of Vapor Compression Refrigeration system are as follows:

1. Compressor
2. Condenser
3. Expander
4. Evaporator

CONDENSER: These are the most important component of a refrigerator as it is used to change the phase of refrigerant from vapor to liquid at constant pressure. It actually cools the vapor and let it to condense into liquid. Condensers play an important role not only in refrigerators but also in various fields like power plants, nuclear plants, air conditioners etc. talking about the domestic refrigerators they are assembled at the back side of refrigerator.



They are of following three types:

1. Air cooled condensers
2. Water cooled condensers
3. Evaporative condensers

1. Air cooled condensers: These are the most commonly used condensers used in the domestic refrigerators. These are assembled in the back side of the refrigerator. These are known by their names as the air is used as cooling agent in it. These are highly recommended condensers as they require zero maintenance and install easily.
2. Water cooled condensers: Water cooled condensers are known as water is used as cooling agent in it. They are further classified into two as tube in tube condensers and shell & tube condensers. These are costly and require routine maintenance as the rust is the major factor taken into concern. Continuous cold water is also required for its smooth operation.
3. Evaporative condensers: These are comparatively more effective condensers than the air cooled within the lower cost and low maintenance. They give better results in the limited amount of water. Actually these are the combination of both water cooled and air cooled condensers. It rejects the heat by evaporating water into air stream while passing through the condensing coil. It has a chamber where the water is sprayed over the coils. We can also use a blower fan its better functioning

II. LITERATURE REVIEW

Manpreet Singh, Babool Rai explains the effect of water coold and evaporative cooled condensers for better efficiency as in their final result COP is improved by 1.5-10.2%. They explains that higher the pressure drop result higher COP.

Dr. Dheya Ghanim Mutasher Paper describes the method to increase the performance of domestic refrigerator using shell and tube type heat exchanger. On the basis of parameter such as flow rate, compressor work, temperature the COP is evaluated. R-12 is to be used for the aspect of investigation purpose to used it in domestic refrigerator.

Sreejith K., T.R. Sreesastha Ram, Rizwan, Sachin M The main aim of this paper is to address the improvement of performance of the domestic refrigerator by using evaporative type condenser which R134ais used as a refrigerant. After the experiment it is observed that the performance of refrigerator is increased by 13.44% by using evaporate type condenser as compared to the air cooled condensers.

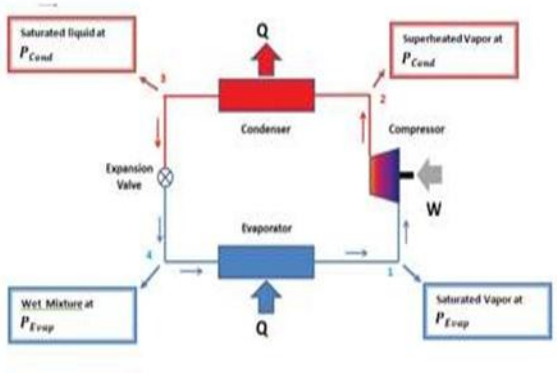
Mr. Sagar Patil Prof. Kiran Devade Here paper ports the hybrid refrigeration system that combines the Thermo Electric Module and Vapour Compression System for enhancing the cooling capacity and also swings the energy. The result of combination of air cooled and water cooled compress along with Thermo electric module is the decrease in energy consumption by 10.92% annually. It means we can save up to 80 units per year.

Prof.Gaffar, G.Momin Paper describes the method to increase the performance of domestic refrigerator using shell and tube type heat exchanger. On the basis of parameter such as flow rate, compressor work, temperature the COP is evaluated. R-12 is to be used for the aspect of a investigation purpose to used it in domestic refrigerator.

Sreejith K This paper tries to cover the experimental investigation of enchantment of performance of domestic refrigerator by using various compress oil linked with water cooled condensers. In the setup mineral oil (SUNISO -3GS) is used against poly-astral oil (POE). It is observed that for various load condition the mineral oil system reduces the energy consumption up to 11%. The hot water out can be used for house hold work.

III EXPERIMENTAL SETUP

For the test procedure domestic refrigerator (Godrej Classic) of capacity 165 liters is used. It consists of evaporator, compressor, condenser and capillary tube with the knob for on-off operation. In this refrigerator R134a and R600a refrigerants are used. The special arrangement for water cooled condenser is done. Water is uniformly spread over the condenser coil.



IV. METHODOLOGY

In the test setup thermocouples are attached for temperature measurement at compressor inlet, compressor outlet, and evaporator and at condenser. A vessel filled with 1 liter of water is kept inside the refrigerator. Its temperature was also noted. Pressure gauge is also provided at inlet and outlet of the compressor. Firstly the readings were taken for refrigerant R134a and then the same procedure was carried out for refrigerant R-600a

V. CALCULATIONS

For R-134A:

(1) Compressor Work (w)

$.w = h_2 - h_1$

$.w = 457.289 - 409.363$

$. w = 47.926\ KJ/Kg$

(2) Refrigeration Effect (RE)

$.RE = h_1 - h_3$

$.RE = 409.363 - 248.793$

$. RE = 160.570\ KJ/Kg$

(3) Coefficient of Performance (COP)

$.COP = \frac{RE}{w} = \frac{h_1 - h_3}{h_2 - h_1}$

$.COP = \frac{160.570}{47.926}$

$.COP = 3.35$

(4) Mass Flow Rate (m_r)

$. m_r = \frac{3.5}{RE}$

$. m_r = \frac{3.5}{160.570}\ Kg/Sec$

$. m_r = 0.021\ Kg/Sec$

For R-600A:

(1) Compressor Work (w)

$.w' = h_{2'} - h_{1'}$

$.w' = 645.073 - 580.179$

$. w' = 64.894\ KJ/Kg$

(2) Refrigeration Effect (RE)

$.RE' = h_{1'} - h_{3'}$

$.RE' = 580.179 - 287.324$

$. RE' = 292.885\ KJ/Kg$

(3) Coefficient of Performance (COP)

$.COP' = \frac{RE'}{w'} = \frac{h_{1'} - h_{3'}}{h_{2'} - h_{1'}}$

$.COP' = \frac{292.885}{64.894}$

$.COP' = 4.513$

(4) Mass Flow Rate ($m_{r'}$)

$. m_{r'} = \frac{3.5}{RE}$

$. m_{r'} = \frac{3.5}{292.885}\ Kg/Sec$

$. m_{r'} = 0.012\ Kg/Sec$

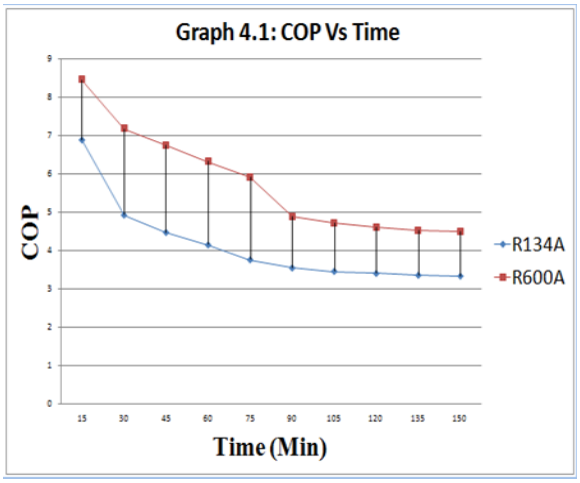
PERCENTAGE CHANGE IN COP:

$=.\frac{COP\ for\ R-600A - COP\ for\ R-134A}{COP\ for\ R-134A} \times 100$

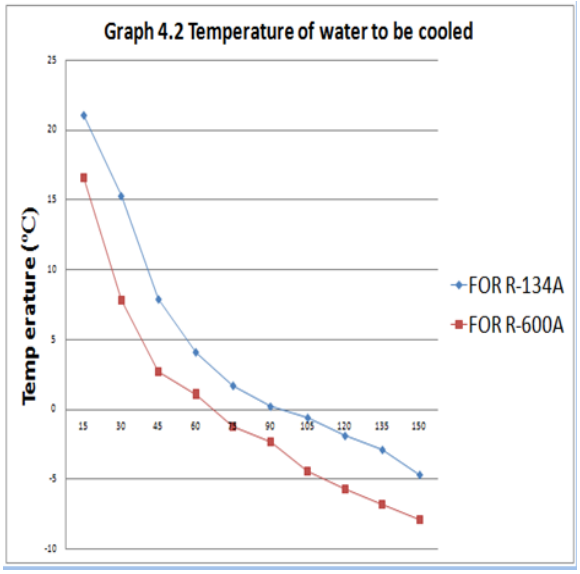
$=.\frac{4.531 - 3.350}{3.350} \times 100$

$=34.716\ \%$

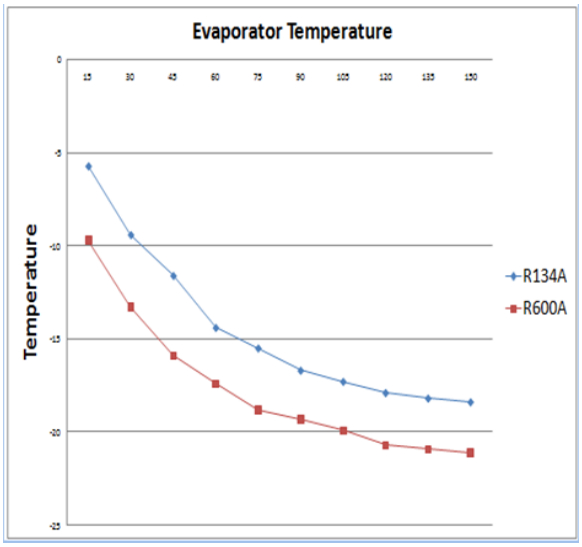
VI. RESULT & DISCUSSION



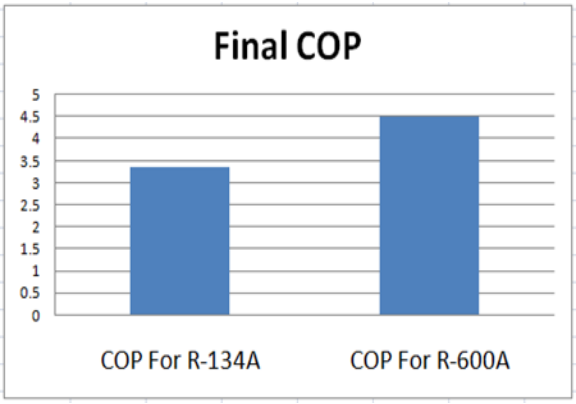
From the above graph, it is clear that the COP refrigerant R-600A is comparatively high than for the refrigerant R-134A at same time instant.



As shown in above Graph refrigerant R-600A shows better results. It provide much more cooling than that of refrigerant R-134A.



As shown in the above Graph the temperature variation of evaporator for both the refrigerants is quite different. Here also refrigerant R-600A shows better result for the same time instant.



The above Graph shows the final COP for both the refrigerants. Refrigerant R-134A 3.35 gives value while refrigerant R-600A gives 4.513

VII. RESULT & DISCUSSION

In this analysis of the domestic refrigerator carried out by using R-134A and R-600A as refrigerant, in order to find the better performance, based on the investigation results, the following conclusion drawn:

(a) COP for refrigerant R-600A is found higher than that for refrigerant R-134A by
34.716% (At Steady State Condition)

(b) Compressor work is also observed lower for refrigerant R-600A

(c) Thus it is concluded that refrigerant R-600A is preferable and efficient for domestic as commercial refrigerators as well.

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