Experimental Analysis of Domestic Refrigerator Using Air cooled and Evaporative Type Condensers

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***Abstract*- The main aim of this article is to analyze the performance of refrigerator connected with air cooled as well as evaporative type condenser. As refrigerator uses the vapor compression cycle in its process. The performance of this system becomes the main problem and many investigations are still under way to evaluate and improve the efficiency of the system. This article presents the effect of the evaporative condenser in the COP of the domestic refrigerator. The purpose of this article is to compare the COP of the refrigerator using an air-cooled condenser and an evaporative condenser of the same length and diameter. 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 evaporative condenser for residential refrigerator was introduced. To allow evaporative cooling, the cotton was wrapped around the condenser to suck the water sprayed onto it. The thermal properties at different points in the refrigeration cycle were measured for typical operating conditions for both air cooled condenser and evaporative type condenser.**

***Index Terms*—Air cooled condenser, Evaporative cooling.**

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

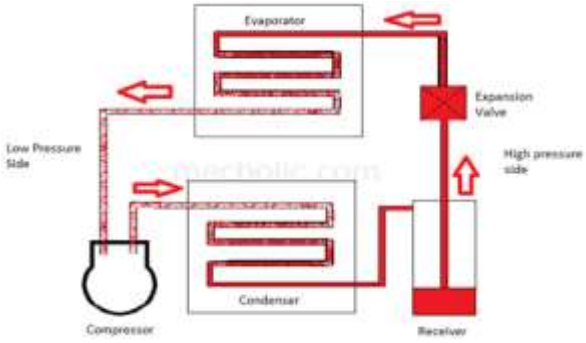

FIG:1 Layout of Domestic refrigerator components

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

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.

(1) 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.

(2) 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

Dr. Dheya Ghanim Mutasher Paper descibe the method to increse 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.

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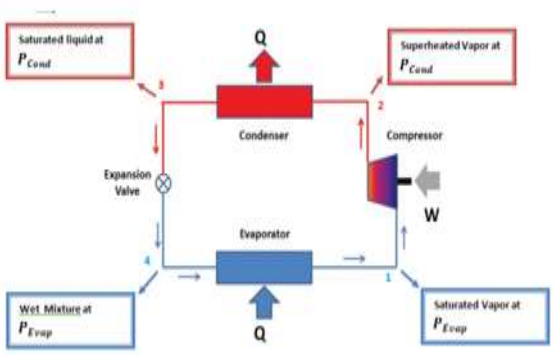
Mr. Sagar Patil Prof. Kiran Devade Here paper port the hybrid refrigeration system that combines the Thermo Electric Module and Vapour Compression System for enhancing the cooling capacity and also swing the energy. The result of combination of air cooled and water cooled compress along with Thermo electric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

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.

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 s 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 refrigerant is used. The special arrangement for evaporative condenser is done. For that purpose the cotton is wound around the condenser coil. Water is uniformly spread over the condenser coil. Fig:2 shows the layout of our setup.



IV. METHODOLOGY

In the test setup thermocouples are attached for temperature measurement at compressor inlet, compressor outlet, evaporator and at condenser. A vessel filled with 500 ml 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 air cooled condenser and then the same procedure was carried out for evaporative type condenser.

V. CALCULATIONS

(a) For air cooled condenser

(1) Compressor Work (w)

$.w = h_2 - h_1$

$.w = 454.549 - 409.681$

$. w = 44.868\ KJ/Kg$

(2) Refrigeration Effect (RE)

$.RE = h_1 - h_3$

$.RE = 409.681 - 249.822$

$RE = 159.799\ KJ/Kg$

(3) Coefficient of Performance (COP)

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

$.COP = \frac{159.799}{44.868}$

$.COP = 3.56$

(4) Mass Flow Rate (m_r)

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

$. m_r = \frac{3.5}{159.799} Kg/min$

$. m_r = 0.021\ Kg/Sec$

(b) For evaporative type condenser

(1) Compressor Work (w)

$.w = h_2 - h_1$

$.w = 441.384 - 409.31$

$w = 32.074\ KJ/Kg$

(2) Refrigeration Effect (RE)

$.RE = h_1 - h_3$

$.RE = 409.31 - 251.298$

$RE = 158.012\ KJ/Kg$

(3) Coefficient of Performance (COP)

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

$.COP = \frac{158.012}{32.074}$

$.COP = 4.92$

(4) Mass Flow Rate (m_r)

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

$. m_r = \frac{3.5}{158.012} Kg/min$

$. m_r = 0.022\ Kg/Sec$

Where h_1 =Specific Enthalpy at the inlet of compressor (KJ/Kg)

h_2=Specific Enthalpy at the outlet of compressor (KJ/Kg)

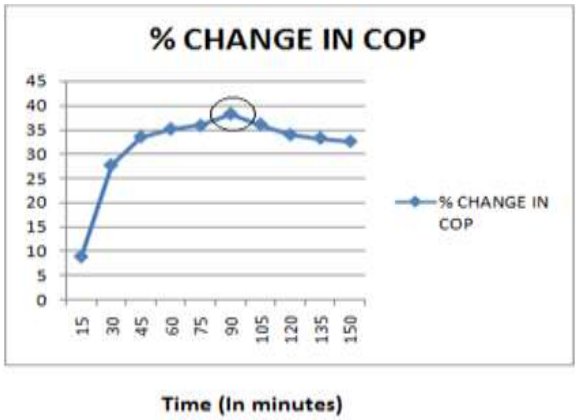
h_3 =Specific Enthalpy at the outlet of condenser (KJ/Kg)

The values of h_1, h_2, and h_3 is calculated using RAC DATA BOOK for 134-a during the calculation for optimum point.

$.Percantage\ change\ in\ COP = \frac{Final\ COP - Initial\ COP}{Initial\ COP} \times 100 = \frac{4.92 - 3.56}{3.56} \times 100$

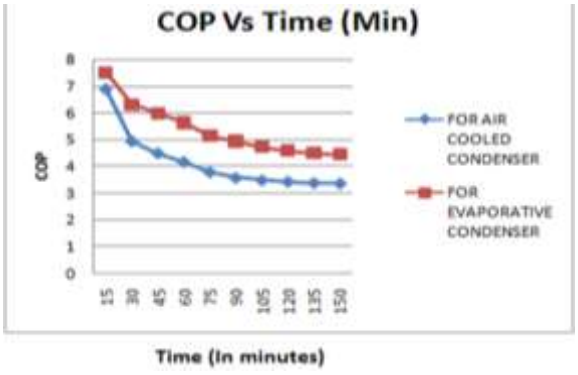
$.Percantage\ change\ in\ COP = 38.27\ \%$

VII. RESULT & DISCUSSION



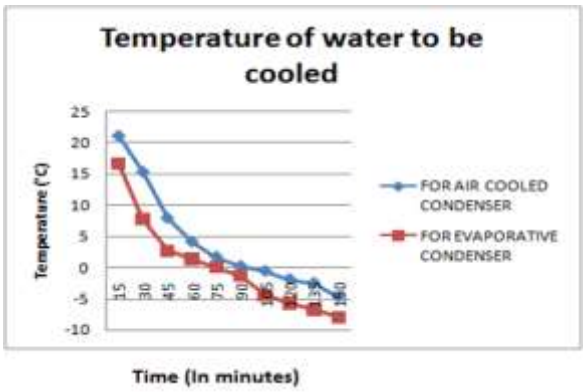
Graph: 1 Percentage change in COP

Graph:1 shows the % change in COP in different time instants. The encircled point is optimum point as it has the maximum percentage increment.



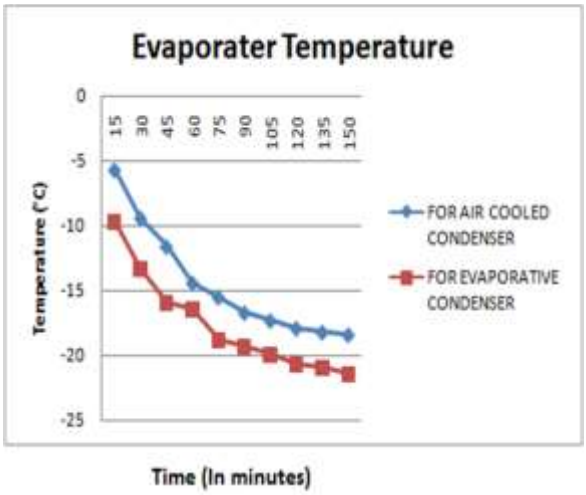
Graph: 2 COP of Air cooled and evaporative condenser.

From Graph:2 It is clear that the COP of evaporative is comparatively high than air cooled condenser at same time instant.



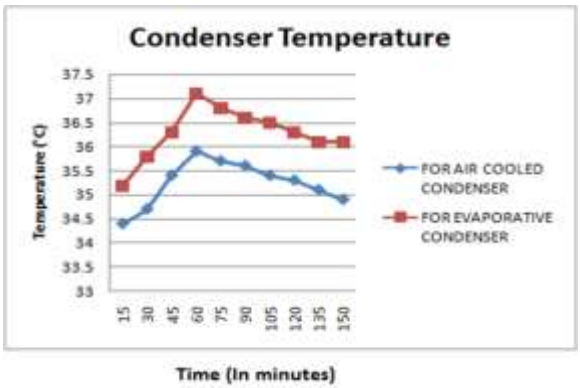
Graph: 3 Temperature of water to be cooled.

As shown in Graph:3 evaporative condenser shows better results. It provide much more cooling than that of air cooled type.



Graph: 4 Evaporator temperature for air cooled condenser and evaporative condenser.

As shown in Graph: 4 the temperature variation of evaporator for both the condenser is quite different. Here also evaporative type condenser shows better result for the same time instant.



Graph: 5 Condenser temperature for air cooled and evaporative condenser.

From Graph: 5 it is observed that with evaporative condenser, the condenser temperature value had the lowest temperature values than with air cooled condenser.

VIII. CONCLUSION

In this analysis of the domestic refrigerator carried out by using air cooled and evaporative condenser in order to find the better performance, based on the investigation results, the following conclusion drawn:

(a) COP of evaporative type condenser is found higher than that of air cooled condenser by 38.27% (maximum at optimum point)

(b) Energy consumption for evaporative condenser is also lower than that of air cooled condenser by 2.14%

(c) Compressor work is also observed lower for evaporative type condenser.

(d) Thus it is concluded that evaporative condenser is preferable safe and efficient for domestic as commercial refrigerators as well.

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