COP ANALYSIS OF DOMESTIC REFRIGERATOR USING DIFFERENT REFRIGERANT

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Abstract- Refrigeration technology, do the best work of stopping the rapid multiplications of the bacteria, which helps or benefits to the society of the changes of falling ill from bacteria illnesses are, reduces. These articles present the comparison of the coefficient of performance of refrigerator system, which is based on vapor compression cycle. So in this research work, using the refrigerator test rig and obtain the performance of the domestic refrigerator in terms of coefficient of performance (COP), firstly, theoretically analyzing the two important operating conditions parameter which are temperature and pressure, and secondly carry out the experimentation using these parameters for two different refrigerants, namely R134a and R152a.

Keywords- Refrigeration; compression cycle; coefficient of performance (COP); refrigerants

I. INTRODUCTION

Refrigeration can be said to the process of heat removal from substances. It is done with the aim of lowering the temperature of the substance and maintaining that lower temperature [1]. Refrigeration in food is done to reduce the risk of bacteria survival. Bacteria are responsible for most of the illnesses. Refrigeration has been associated with a lot of benefits in our homes and in the society at large. Many homes in our country are now equipped with a refrigerator. The very first artificial refrigeration known was the demonstration presented at the University of Glasgow by William Cullen in 1748. This discovery however was not use for any practical purpose. The first refrigerator was designed by Oliver Evans, an American inventor in 1748. But the first practical refrigerator was built in 1834 by Jacob Perkins [2-3].

Thermodynamic processes in refrigeration system release large amounts of heat to the environment. Heat transfer between the system and the surrounding environment takes place at a finite temperature difference, which is a major source of irreversibility for the cycle. Irreversibility causes the system performance to degrade. The losses in the cycle need to be evaluated considering individual thermodynamic processes that make up the cycle. Energy analysis is still the most commonly used method in the analysis of thermal systems [4-5]. The first law is concerned only with the conservation of energy, and it gives no information on how, where, and how much the system performance is degraded. Exergy analysis is a powerful tool in the design, optimization, and performance evaluation of energy systems [6]. The principles and methodologies of exergy analysis are well established. An exergy analysis is usually aimed to determine the maximum performance of the system and identify the sites of exergy destruction. Analyzing the components of the system separately can perform exergy analysis of a complex system. Identifying the main sites of exergy destruction shows the direction for potential improvements [7-10].

Refrigeration is an old technology that started a long time ago. Refrigeration concept can be said to originate from the prehistoric times [11]. The refrigeration technology can be said to have a great impact to women in particular. This is because women are viewed as the domestic workers in Cowan, 137-138. Though this mentality has changed in the modern world, there is still the thought that the domestic world belongs to women. The

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refrigerants use in the refrigerators has a negative effect on the environment [12-14]. Though the use of **Chloro-Fluoro-Carbons** (CFC) has been banned, some manufactures may sell the old stock of refrigerators which use CFC. These are detrimental to the ozone layer [15].

The HCFs being used on modern refrigerators are strong green house gas emitters. Refrigeration has allowed many families and industries to keep food fresh for long periods of time. It is a symbol of growth in the most families is small and they occupy a small piece of land and hence there is no space for keeping livestock and growing different varieties of fruits and vegetables [16-18]. Government as a regulator- the government through the Environment protection agency has set standard for monitoring and regulating refrigerant leaks. Government as consumer-many government buildings, both central and federal government, is installed with air conditioners, refrigerators and other heating and cooling systems that use the refrigeration technology. Different researchers suggested few HFC and HC refrigerants as suitable alternative to these CFC and HCFC refrigerants. Properties of some HFC and HC refrigerants with zero ODP and relatively less GWP as compared to CFC and HCFC refrigerants. Experimentally investigated the exergetic performance of a domestic refrigeration system using R 12 [19-23].

II. WORKING PRINCIPLE

A refrigerator works by passing a cool refrigerant gas around food items (kept inside the fridge), which absorb heats from them and then loses that heat to the relatively cooler surroundings on the outside (figure 1). The working principle of a refrigerator (and refrigeration, in general) is very simple: it involves the removal of heat from one region and its deposition to another. When you pass a low-temperature liquid close to objects that you want to cool, heat from those objects is transferred to the liquid, which evaporates and take away the heat in the process (figure 2).
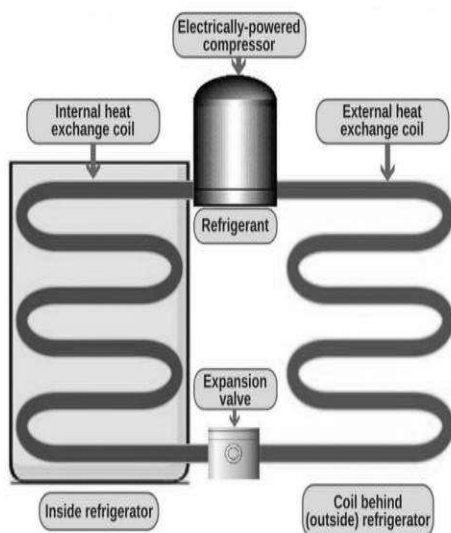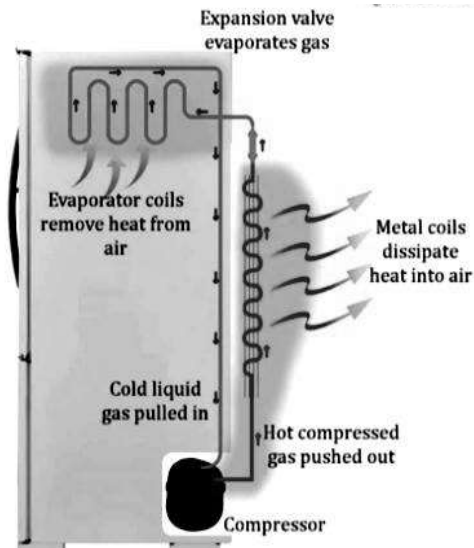

Fig. 1: Refrigerator model [1]

Fig. 2: Refrigerator indicating internal components

III. VAPOR COMPRESSION REFRIGERATION SYSTEM (VCRS)

It is defined as the process of removing heat from a body or enclosed space so that the temperature first lowered and then maintained at level below the temperature of surrounding. The equipment used to maintain the required temperature is called refrigerating equipment. There are two types, Vapor Compression Refrigeration System (VCRS) and Vapor Absorption Refrigeration System (VARS). The refrigerant, which is now in a liquid state, passes through the expansion valve and turns into a cool gas due to the sudden drop in pressure. As the cool refrigerant gas flows through the chiller cabinet, it absorbs the heat from the food items inside the fridge and vaporizes. The refrigerants, which is in gaseous form, flows into the compressor, which sucks it inside the compresses the molecules together to make it into a hot, high-pressure gas.

[A] Internal Parts

The internal parts of a refrigerator are ones that carry out actual working of the refrigerator. Some of the internal parts are located at the back of the refrigerator, and some inside the main compartment of the refrigerator. A refrigerator consists of a few key components that play a vital role in the refrigeration process (Figure 3).

[B] Refrigerant

The working substance used to make refrigeration is called refrigerant. The refrigerant runs through all the inner part of the refrigerator. It is the refrigerant that carries out the cooling effects in the evaporator. It absorbs the heat from the body to be cooled in the evaporator (chiller or freezer) and throws it to the atmosphere via condenser. The refrigerant keeps on re-calculating through all the inner parts of the refrigerator in cycle and they are the compressor; the evaporator; the condenser; the expansion valve and the defrost System.
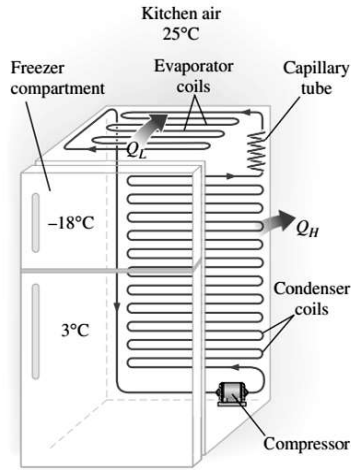

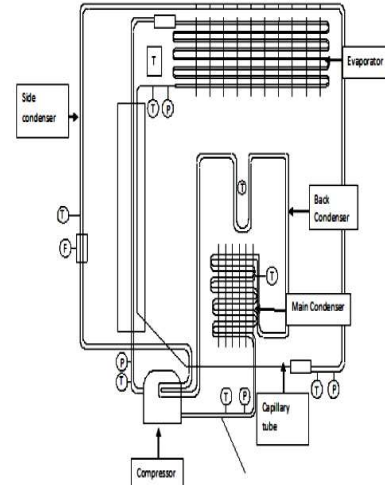Fig. 3: Vapor compression refrigeration system [12]

Fig.4: Line diagram of refrigeration setup [9]

IV. EXPERIMENT SETUP AND METHODOLOGY

To analyze the effect and carry out the variation using the various parameters like the different refrigerant at particular temperature and pressure. The standard refrigeration specification has been tabulated in Table 1. The hermetic sealed compressor is used and the two refrigerants, namely *R134a* and *R152a*. The Refrigerant *R134a* is a hydro-fluorocarbon (HFC), which has zero potential towards the ozone layer and has very little greenhouse effect. It is the non-flammable and non-explosive, has toxicity within limits and good chemical stability. It has good affinity for the moisture. The overall physical and thermodynamic properties of refrigerant *R134a* is excellent in various phases in refrigerator and hence we choose R134a. Similarly, *R152a* is most commonly used as a component within other refrigerant blends, as a propellant, and in some XPS foams. Its relatively low global warming potential when compared to other HFCs is desirable, however its flammability creates challenges thus limiting its use. We choose this refrigerant as to compare with Refrigerant *R134a*. The working model in terms of line diagram is shown in figure 4. In this, *T* and *P*, respectively represent the Temperature and Pressure Point. The experimental setup is practically farmed as shown in figure 5, in which the Temperature gauge *(T)* and Pressure gauge *(P)* is being attached at the various point, mentioned in the line diagram.

Fig.5: Condenser measuring unit of Refrigerator

Table 1: The Specification(s) of Refrigerator Model

SN.	Particulars	Specifications
1	Brand	Whirlpool
2	Model name/year	DC-5256-2013
3	Freezer capacity	80 liter
4	Fresh food compartment capacity	230 liter
5	Power rating	160 watt
6	Current rating	0.9 Ampere
7	Voltage	220-240 volt
8	Frequency	50 Hz
9	No of doors	Double
10	Compressor	Hermetic-sealed
11	Refrigerant type	R134a and R152a

V. EXPERIMENTAL PROCEDURE

This section provides the information about the how the experiment setup is carried out the test procedure during experiment. Firstly, the experiment test rig developed from the refrigerator model. To perform the experiment, the test rig of 230L refrigerator is selected as shown in figure 5. By using the refrigeration setup line diagram as shown in figure 4, the various connection point of pressure and temperature measurement is made. The 6 point for temperature measurement and 2 point of pressure measurement is prepared in which the one point is in suction side and another point is in discharge line.

The pressure gauge are used for the pressure measurement so compound gauge is fitted on discharge line due to high pressure and vacuum gauge is fitted on suction line due to low pressure as shown in the figure 5. Now there five points is temperature measurement, first point of temperature measurement is in evaporator means in the freezer compartment or refrigerator. Second, third, fourth and fifth point is for the measurement of food storage cabinet, this point is located, respectively on the compressor inlet, compressor outlet, and condenser inlet and condenser outlet. Sixth point is for the temperature measurement digital thermometer is used for ambient. Ammeter is also used for the current measurement. This is the procedure of the experiment set up. Now for the test procedure the evacuation and vacuuming is done by another compressor. And vacuum is done up to the 25 in/hg. This is required for the cleaning of the lines by removing moisture, air and oil. Now after that the refrigerant is charged by the charging

system and when the evaporator temp. set at 10oC and using the first refrigerant as R134a in the refrigerator unit and collected the data like pressure and temperature every 15 minutes during the running the refrigerator and also collected the data various evaporator temperature.
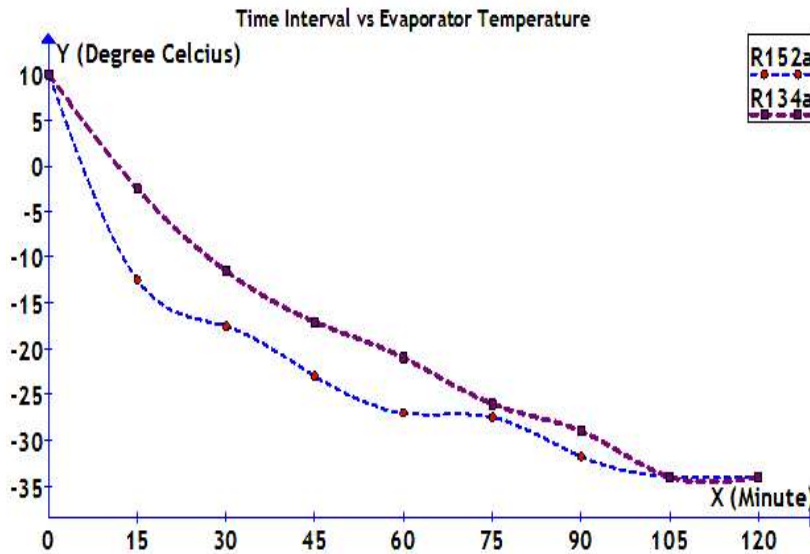

Fig.6: Time interval vs Evaporator Temperature

VI. RESULTS AND DISCUSSIONS

To improve the coefficient of performance, it is requires that the compressor work should decrease and refrigeration effect should increase. It means that decrease in condenser pressure and temperature so the refrigeration effect will increase and compressor input work due to this COP will increase. And also increase in pressure and temperature of evaporator the work input will decrease and refrigeration effect will increase due to this COP will increase for a vapor-compression refrigeration system.
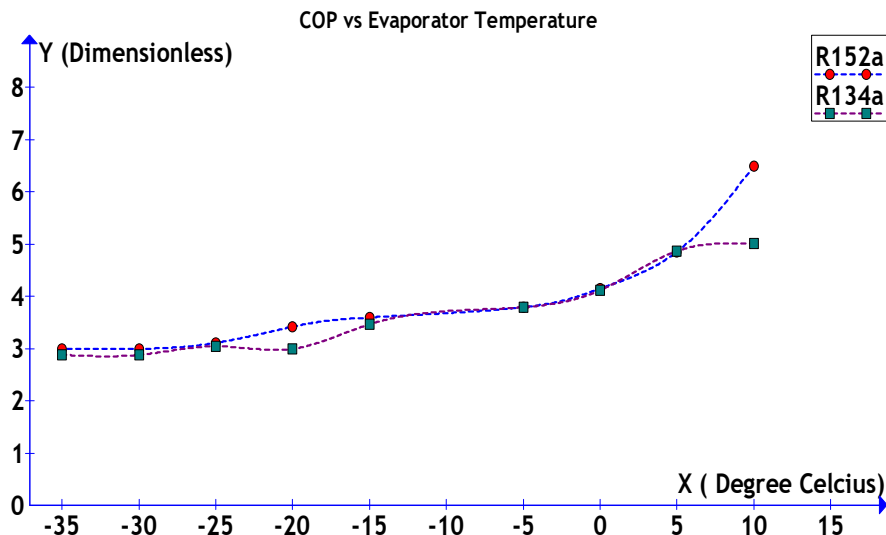

Fig.7: COP vs Evaporator Temperature

The evaporator vessel was submerged in a liquid from which the heat required to vaporize the ether was extracted, thereby cooling the liquid. It is found that decrease in condenser pressure and temperature so the refrigeration effect will increase and compressor input work due to this cop will increase. And also increase in pressure and temperature of evaporator the work input will decrease and refrigeration effect will increase due to this

cop will increase for vapor-compression refrigeration. The record of the evaporator temperature at regular interval of 15 minutes is noted down under the ambient temperature. They represent the evaporator temperature for the refrigerant R134a and R152a. The calculation has been done using the mechanical formulas and the following graphs have been prepared, which shows in figure 6, 7 and 8.
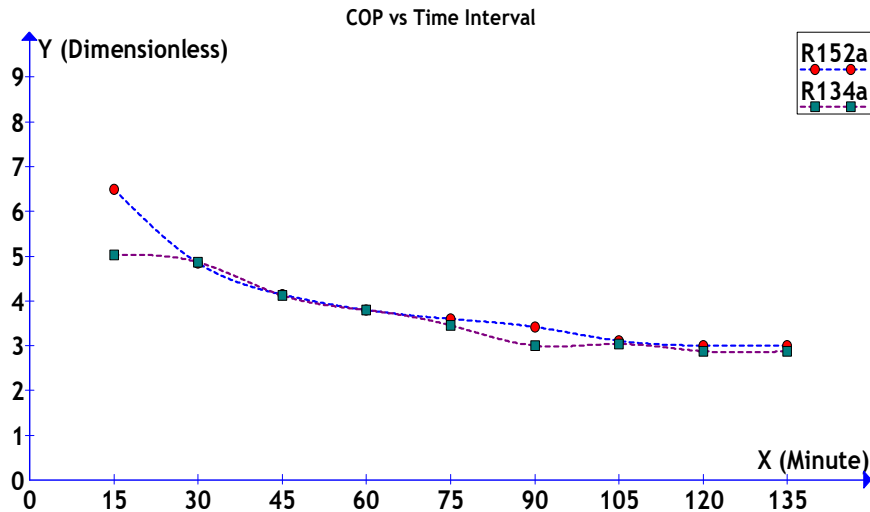

Fig. 8 COP vs Time Interval

VII. CONCLUSION

In this study performance analysis of the domestic refrigerator carried out by using various two refrigerants in order to find the alternate of R 134a. Based on the investigation results, the following conclusion has drawn: The COP of the R 152a Refrigerant is 17% is high than the R134a. The refrigerant R134a and R 152a has nearly same refrigerant effect after particular span of time. The electric power consumption is low for R152a and 18 % lower than the R134a. The work done by the compressor is low for the R134a around the 39.13 KJ/Kg and the work done by the R152a is slightly higher around the 17%.

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