A REVIEW PAPER EXPERIMENTAL ANALYSIS ON THE CONDENSER FINS FOR HOUSEHOLD REFRIGERATED SYSTEM

[1]Yogesh Rathore, **[2]Dhananjay Yadav,[3]Anil Verma**

[1] M.tech Schlor, Mechanical Department, SSSUTMS, M.P.India
[2] Assistant Professor, Mechanical Department, SSSUTMS, M.P.India
[3] Assistant Professor, Mechanical Department, SSSUTMS, M.P.India

ABSTRACT

The main objective of the present work is to increase the performance of the condenser by increasing the heat transfer rate through the condenser. Heat transfer rate can be increased by the extended surfaces called fins. Heat transfer rate is also depends on the spacing between the fins of the condenser. In the present experimental work several condensers having different fins spacing are taken. By using this parameter experiments are conducted on a domestic refrigerator of capacity 165liters. The effect of varying the condenser fins spacing on the performance of refrigerator condenser is calculated experimentally. to do so 4mm, 6mm & 9mm condenser spacing are taken and behavior of refrigerator was checked with help of parameters

Keywords— *pull down time, COP, compressor discharge pressure, energy consumption.*

INTRODUCTION

In India and Egypt evaporative cooling was employed. If a liquid is rapidly vaporized, it expands quickly. The rising molecules of vapour abruptly increase their kinetic energy. Much of this increase is drawn from the immediate surroundings of the vapour, which are therefore cooled. Thus, if water is placed in shallow trays during the cool tropical nights, its rapid evaporation can cause ice to form in the trays, even if the air does not fall below freezing temperatures. By controlling the conditions of evaporation, it is possible to form even large blocks of ice in this manner. Cooling caused by the rapid expansion of gases is the primary means of refrigeration today. The technique of evaporative cooling, as described heretofore, has been known for centuries, but the fundamental methods of mechanical refrigeration were only discovered in the middle of the 19th century. The first known artificial refrigeration was demonstrated by William Cullen at the University of Glasgow in 1748. Cullen let ethyl ether boil into a partial vacuum; he did not, however, use the result to any practical purpose. In 1805 an American inventor, Oliver Evans, designed the first refrigeration machine that used vapour instead of liquid. Evans never constructed his machine, but one similar to it was built by an American physician, John Gorrie, in 1844.

Commercial refrigeration is believed to have been initiated by an American businessman, Alexander C. Twinning, in 1856. Shortly afterward, an Australian, James Harrison, examined the refrigerators used by Gorrie and Twinning and introduced vapour-compression refrigeration to the brewing and meat-packing industries. A somewhat more complex system was developed by Ferdinand Carréof France in 1859. Unlike earlier vapour-compression machines, which used air as a coolant, Carré’s equipment contained rapidly expanding ammonia. (Ammonia liquefies at a much lower temperature than water and is thus able to absorb more heat.) Carré’s refrigerators were widely used, and vapour-compression refrigeration became, and still is, the most widely used method of cooling.

DOMESTIC REFRIGERATION SYSTEM:

The domestic refrigerator is one found in almost all the homes for storing food, vegetables, fruits, beverages, and much more. The parts of domestic refrigerator can be categorized into two categories: internal and external.

INTERNAL PARTS OF THE DOMESTIC REFRIGERATOR:

The internal parts of the 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.

1. **Refrigerant**: The refrigerant flows through all the internal parts of the refrigerator. It is the refrigerant that carries out the cooling effect in the evaporator. It absorbs the heat from the substance to be cooled in the evaporator (chiller or freezer) and throws it to the atmosphere via condenser. The refrigerant keeps on recirculating through all the internal parts of the refrigerator in cycle.

2. **Compressor**: The compressor is located at the back of the refrigerator and in the bottom area. The compressor sucks the refrigerant from the evaporator and discharges it at high pressure and temperature. The compressor is driven by the electric motor and it is the major power consuming devise of the refrigerator.

Fig 1.1 general view of compressor

3. **Condenser**: The condenser is the thin coil of copper tubing located at the back of the refrigerator. The refrigerant from the compressor enters the condenser where it is cooled by the atmospheric air thus losing heat absorbed by it in the evaporator and the compressor. To increase the heat transfer rate of the condenser, it is finned externally.

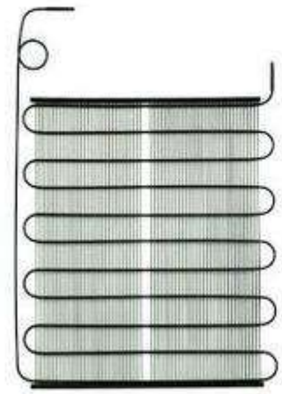


Fig 1.2 general view of condenser

EXTERNAL VISIBLE PARTS OF THE REFRIGERATOR:

1. **Freezer compartment**: The food items that are to be kept at the freezing temperature are stored in the freezer compartment. The temperature here is below zero degree Celsius so the water and many other fluids freeze in this compartment. If you want to make ice cream, ice, freeze the food etc. they have to be kept in the freezer compartment.

2. **Thermostat control**: The thermostat control comprises of the round knob with the temperature scale that help setting the required temperature inside the refrigerator. Proper setting of the thermostat as per the requirements can help saving lots of refrigerator electricity bills.

3. **Refrigerator compartment**: The refrigerator compartment is the biggest part of the refrigerator. Here all the food items that are to be maintained at temperature above zero degree Celsius but in cooled condition are kept. The refrigerator compartment can be divided into number of smaller shelves like meat keeper, and others as per the requirement.

4. **Crisper**: The highest temperature in the refrigerator compartment is maintained in the crisper. Here one can keep the food items that can remain fresh even at the medium temperature like fruits, vegetables, etc.

5. **Refrigerator door compartment**: There are number of smaller subsections in the refrigerator main door compartment. Some of these are egg compartment, butter, dairy, etc.

6. **Switch**: This is the small button that operates the small light inside the refrigerator. As soon the door of the refrigerator opens, this switch supplies electricity to the bulb and it starts, while when the door is closed the light from the bulb stops. This helps in starting the internal bulb only when required.

VAPOUR COMPRESSION REFRIGERATION SYSTEM:

The basic components of a modern vapour-compression refrigeration system are a compressor; a condenser; an expansion device, which can be a valve, a capillary tube, an engine, or a turbine; and an evaporator. The gas coolant is first compressed, usually by a piston, and then pushed through a tube into the condenser. In the condenser, the winding tube containing the vapour is passed through either circulating air or a bath of water, which removes some of the heat energy of the compressed gas. The cooled vapour is passed through an expansion valve to an area of much lower pressure; as the vapour expands, it draws the energy of its expansion from its surroundings or the medium in contact with it. Evaporators may directly cool a space by letting the vapour come into contact with the area to be chilled, or they may act indirectly. By cooling a secondary medium such as water. In most domestic refrigerators, the coil containing the evaporator directly contacts the air in the food compartment. At the end of the process, the hot gas is drawn toward the compressor.

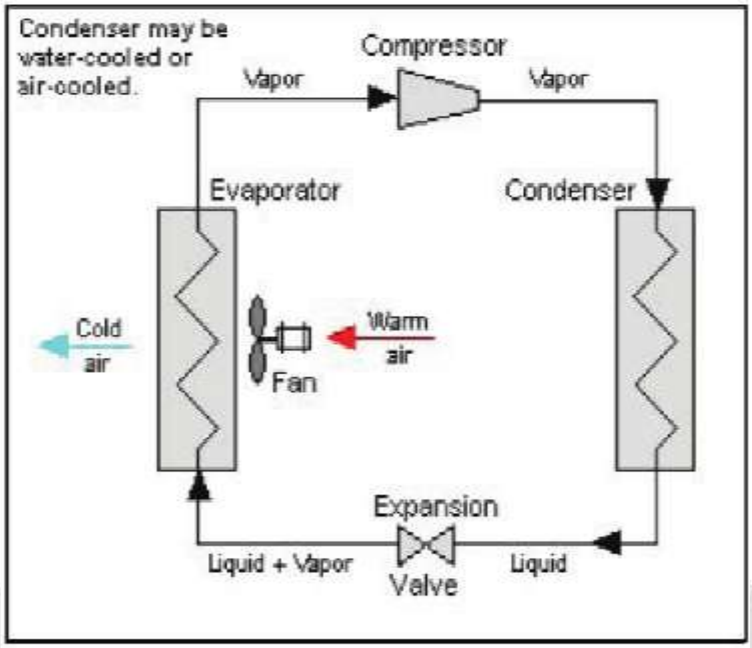


Fig 1.8 block diagram of vapour compression refrigeration system

T-S and P-h Diagram of "VCRS"

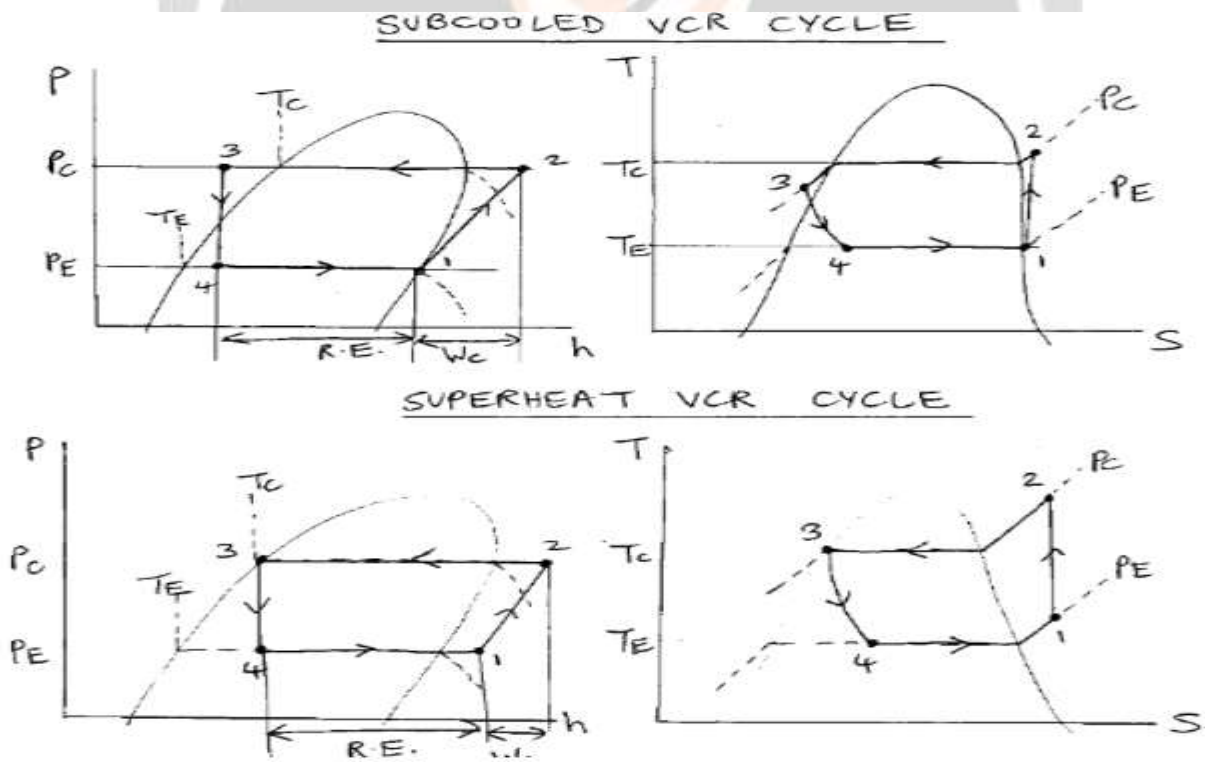


Fig 1.9P-H & T-S diagram of VCRS

1. **PROCESS 1-2: ISENTROPIC COMPRESSION IN COMPRESSOR**
2. **PROCESS 2-3: CONSTANT PRESSURE HEAT REJECTION IN CONDENSER**
3. **PROCESS 3-4: THROTTLING PROCESS IN EXPANSION VALVE**
4. **PROCESS 4-1: CONSTANT PRESSURE HEAT ADDITION IN EVAPORATOR**

LITERATURE REVIEW

Chandrashekhar M. Bagade et al (2012) Day by day there is increasing demand of refrigerating effect which increases the load on compressor. But sub cooling and superheating are the process used for getting maximum refrigerating effect, ultimately improve COP of the refrigerating system. Condenser plays an important role in any refrigeration system .it is use to remove heat from refrigerant vapour coming from compressor p-h and T-s diagrams clearly shows, the effect of sub cooling after condensate formation on COP. Now a day we are interested in improving COP of refrigeration system, without affecting compressor work. Sub cooling is one of the factors that can improve the COP of refrigeration system. Sub cooling is done in the condenser, thus condenser design is the key factor to improve the COP of domestic refrigerator.

P. Sarat Babu et al (2013) The condenser design plays a very important role in the performance of a vapour compression refrigeration system. Optimized design is possible through theoretical calculations, however may fail due to the reason that the uncertainties in the formulation of heat transfer from the refrigerant inside the condenser tubes to the ambient air. Hence experimental investigations are the best in terms of optimization of certain design parameters. In my experimental work, it is proposed to optimize condenser length for domestic refrigerator of 165 litres capacity. It may give a chance to find a different length other than existing length will give better performance and concluded that the optimum length of coil is 7.01m.

In the present work, the length of the condenser is optimized for a vapour compression refrigeration system used for a domestic refrigeration of 165 Litres capacities, through experimental investigation. Theoretical computation are also made and compared and found that the optimum length of coil is 7.01 m instead of standard value 6.1m.

P. Saji Raveendran et al (2013) In view of Kyoto protocol, there is a pressing need to reduce the energy consumption and environmental impacts of domestic appliances. In the total energy consumption of household appliances, domestic refrigerator plays a vital role. Alternate refrigerants and improvement in the performance of the components can contribute to tackle the above issue in a domestic refrigeration system. In this paper, the performance of a domestic refrigeration system with brazed plate heat exchanger as condenser, and working with refrigerants such as R290/R600a and R134a was studied using experimental method. The result showed that the system with water-cooled brazed plate heat exchanger reduces the per day energy consumption of a system from 21% to 27% and increases the COP from 52% to 68%, when compared to conventional system. The compressor discharge temperature and dome temperature are also dampened. For R134a and R290/R600a, the TEWI of the system with water-cooled brazed plate heat exchanger is lower than that of the system with air-cooled condenser by 26.8% and 21%, respectively. Among the refrigerants, R290/R600a showed higher performance than R134a.

Sreejith K (2014) The objective of this paper was to investigate experimentally the effect of different types of compressor oil in a domestic refrigerator having water cooled condenser. The experiment was done using HFC134a as the refrigerant , Polyol-ester oil (POE) oil which is used as the conventional lubricant in the domestic refrigerator and SUNISO 3GS mineral oil as the lubricant alternatively. The performance of the domestic refrigerator and HFC134a/POE oil system was compared with HFC134a/SUNISO 3GS mineral oil system for different load conditions. The result indicates that the refrigerator performance had improved when HFC134a/SUNISO 3GS mineral oil system was used instead of HFC134a/POE oil system on all load conditions. The HFC134a/SUNISO 3GS mineral oil works normally and safely in the refrigerator. HFC134a/SUNISO 3GS mineral oil system reduced the energy consumption when compared with the HFC134a/POE oil system between 8% and 11% for various load conditions. There was also an enhancement in coefficient of performance (COP) when SUNISO 3GS mineral oil was used instead of POE oil as the lubricant. The water cooled heat exchanger was designed and the system was modified by retrofitting it, instead of the conventional air-cooled condenser by making a bypass line and thus the system can be utilized as a waste heat recovery unit. The hot water obtained can be utilized for household applications like cleaning, dish washing, laundry, bathing etc. Experimental result shows that about 200 litres of hot water at a temperature of about 58ºC over a day can be generated and thus the system signifies the economic importance from the energy saving point of view.

Akshay Gurav et al (2014) Refrigerator has become an essential commodity rather than luxury item. It is one of the home appliance utilizing vapour compression cycle in it process. Performance of this system becomes main issue and many researches are still ongoing to evaluate and improve efficiency of the system. This paper presents effect of evaporative condenser on COP of domestic refrigerator. The purpose of this article is to compare the COP of refrigerator by using air cooled condenser and evaporative condenser of same length and same diameter. This experiment is carried out on domestic refrigerator (150 liter) test rig. In this study, an innovative, evaporative condenser for residential refrigerator was introduced. A vapor compression cycle incorporating the proposed evaporative condenser was tested to evaluate the cycle performance. To allow for evaporative cooling, sheets of cloth were wrapped around condenser to suck the water sprayed on it. The thermal properties at the different points of the refrigeration cycle were measured for typical operating conditions.

P.Saji et al (2014) Residential buildings contribute to the greenhouse gas emissions through the use of energy-intensive products. Household energy consumption and associated emissions can be reduced partly if energy-saving methods are adopted by the occupants. This paper studies the performance of domestic refrigeration system with water-cooled condenser in which the water used for general purposes in a residential building has been considered as the cooling water for the condenser. The circulation quantity of water per day has been varied, and the variation of COP has been studied and presented. The results obtained from the theoretical and experimental studies show that the COP of the system with brazed plate heat exchanger (BPHE) as water-cooled condenser is 57% to 75% higher than that of air-cooled condenser. Moreover, the system with water-cooled BPHE reduces the per day energy consumption of the system from 21% to 27%. The TEWI of the system with water-cooled BPHE is also 5% to 43% lower than that of the system with air-cooled condenser, and thus the building energy-efficiency could be improved by integrating the refrigerator with the general water supply of a residential building.

Elias G et al (2014) In this study a numerical and experimental investigation on the performance of a skin condenser applied to a specific household refrigerator was carried out. To this end, a mathematical model which takes into account the heat transfer to both the environment and the refrigerated compartments was developed. The model uses as input data the internal and external air temperatures, refrigerant mass flow rate, pressure and temperature at the heat exchanger inlet and the condenser geometry to predict the condenser performance. Steady-state energy consumption tests – compressor running continuously with electric heaters being used to create artificial thermal load – were carried out under different operating conditions with the product inside a climate-controlled chamber. Tests were carried out at ambient temperatures of 25°C and 32°C, fresh-food compartment temperatures of 5°C and 10°C, freezer compartment temperatures of -20°C and -15°C and compressor speeds of 3000 rpm and 4500 rpm. Thermograms of the outer steel sheet temperature fields were recorded during the experiments. The model predictions were compared to a set of in-house experimental data with deviations within a ±2% error band. It was found that, on average, 68% of the condenser heat released rate is transferred to the environment while the remaining 32% is transferred to the refrigerated compartments. It was also found that the thermal conductivity of the tape used to attach the tubes plays an important role in determining the heat transfer rate, and the placement of the tubes in the region of the freezer walls should be avoided.

METHODOLOGY:

1. Firstly cleaning is done with the help of nitrogen gas then evacuation is carried out with the help of vacuum pump and refrigerant is charged with the help of charging system.

2. The refrigerator was firstly experimented with 4mm spacing of condenser and tested at various conditions. Same test were repeated with 6mm and 8mm spacing of condenser.

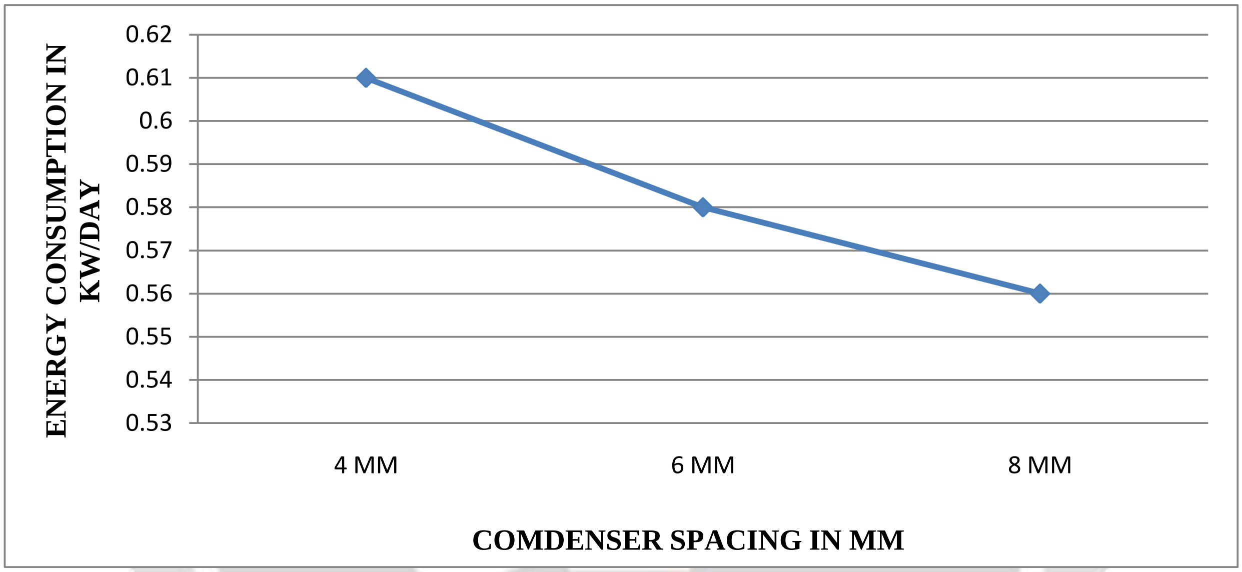
3. During experiment readings obtained from the pressure gauge and temperature sensors at the interval of every five minutes.

4. Readings are taken till the steady state condition.

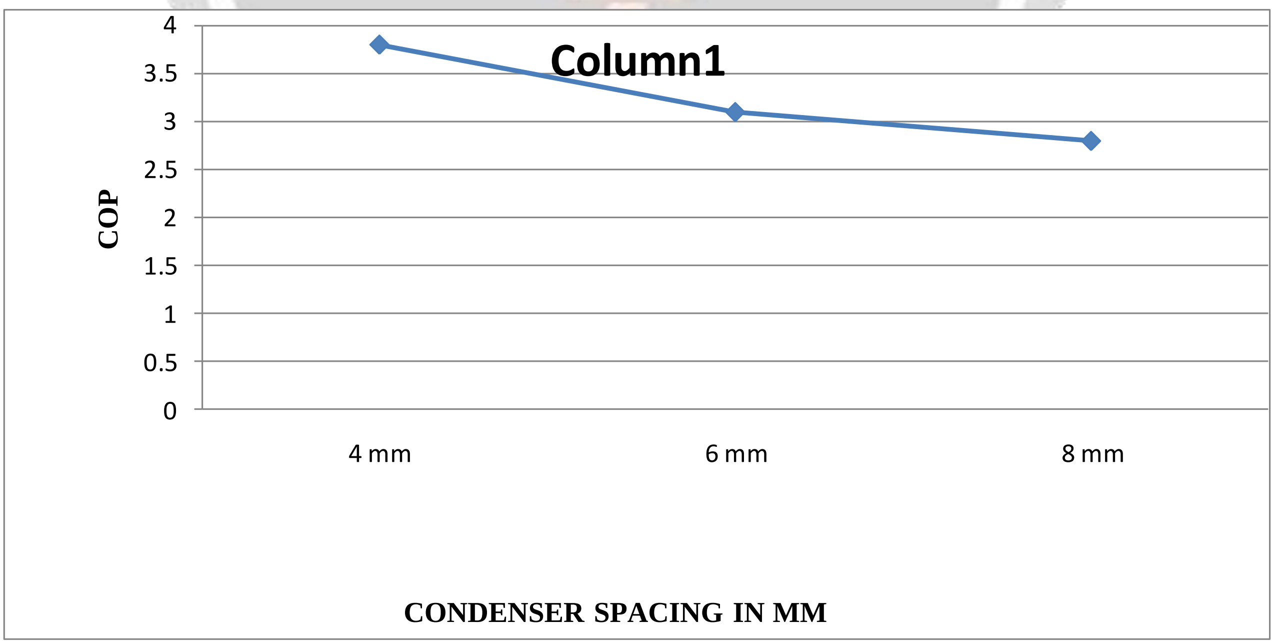
5. After experimenting every spacing leak detection is carried out with the help of soap solution.

RESULTS AND DISCUSSION

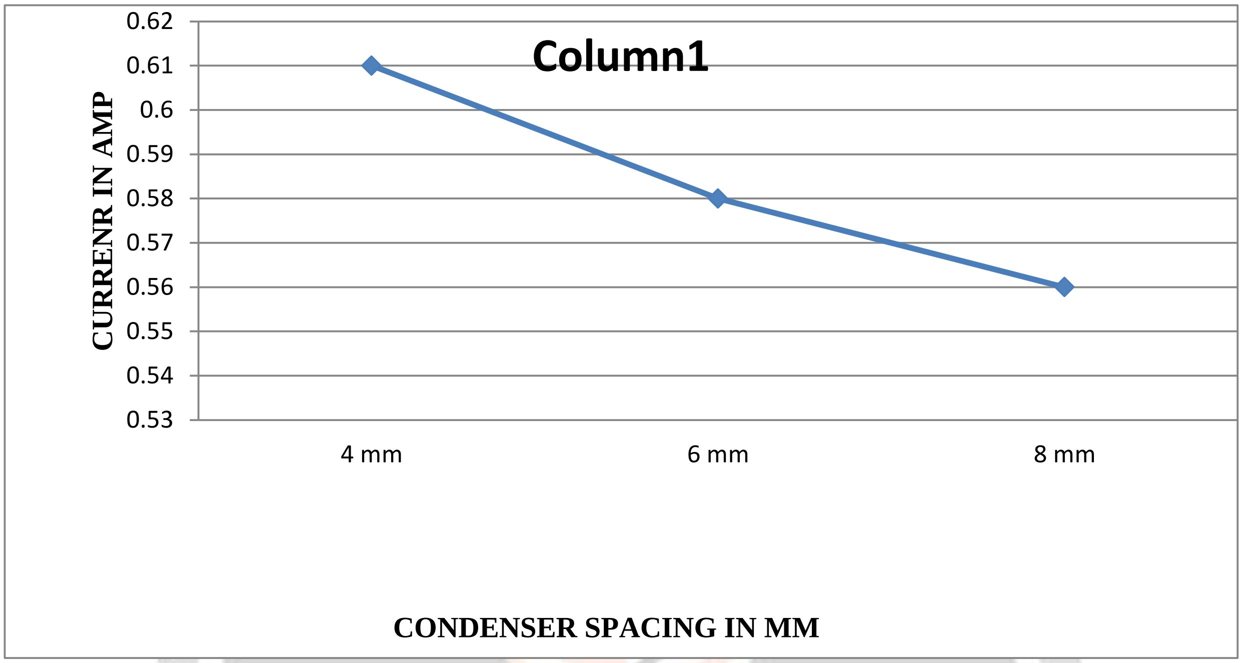
Experimental Results



ENERGY CONSUMPTION FOR 4MM, 6MM AND 8MM CONDENSER SPACING.



COP FOR 4MM, 6MM AND 8MM CONDENSER SPACING.



Capillary tube outlet temperatures FOR 4MM, 6MM AND 8MM CONDENSER SPACING.

CONCLUSIONS

After the successful investigation on the performances of refrigerator with different condenser spacing, the following conclusions can be drawn based on the results obtained:

- **Pull down time of refrigerator.**

- Pull down time at 4mm was 10.05% (5) minute earlier than at 6mm.
- Pull down time at 4mm was 13.32% (10) minute earlier than at 8mm.
- Pull down time at 6mm was 10.52% (5) minute earlier than at 8 mm.

- **Energy consumption of refrigerator.**

- 8mm condenser spacing offers lowest energy consumption. The compressor Consumes 2.22% & 3.12% less energy when 4 mm and 6mm condenser spacing was used in the system, respectively.

- **COP of refrigerator.**

- Overall average COP of 4mm condenser spacing was 4.43% & 4.47% higher than the 6mm & 8 mm condenser spacing

- **Discharge pressure of refrigerator.**

- Discharge pressure of 4mm condenser spacing was less with that of 6mm & 8mm condenser spacing with average percentage reduction of 14.23% & 15.83%

Thus, it is concluded that condenser with 4mm spacing is preferable, and safe viable for domestic and small commercial refrigeration systems with the main advantage that it can be replaced directly without the need to replace or modify any system component.

REFERENCES

1. **Yumrutas R, kunduz M, Kanoglu M**. Exergy analysis of vapor compression refrigeration systems. Exergy, An international journal 2002;2(4);266-72.

2. **Akure, Nigeria** Performance enhancement of a household refrigerator by addition of latent heat storage International Journal of Refrigeration, Volume 31, Issue 5, August 2008, *Pages 892-901* Akintunde, M.A. 2004b. Experimental Investigation of The performance of Vapor Compression Refrigeration Systems. Federal University of Technology,**.**

3. **Granryd E, Conklin JC**. Thermal performance analysis for heat exchangers using nonazeotropic refrigerant mixtures.Heat Transfer in Advanced Energy Systems, ASME Winter Ann Mtg 1990;151:25–32.

4. **Kays WM, London AL**. Compact heat exchangers. New-York: McGraw-Hill, 1984.

5. **Seshimo Y, Fujii M**. An experimental study of the performance of plate fin and tube heat exchangers at low Reynolds numbers. ASME/JSME Thermal Engineering Proceedings, ASME 1991;4:449–54.

6. **Abu Madi M. Johns**, R.A and Heikal M.R (1998).Performance characteristics correlation for round tube and plate finned heat exchangers, int J.Refrigeration.Vol.21(7),pp.507-517.

7. **Achaichia,A and Cowel** ,T.A (1998).Heat transfer and pressure drop characteristics of flat tube and louvered plate fin surfaces ,Exp .Thermal fluid sci.Vol 1(2),pp.147-157.

8. **Chang,W.R Wang C.C** Tsi W.c and Shyu, R.J(1995)Air side performance of louver fin heat exchanger,4 th ASME/JSME Thermal Engineering Joint Conference.Vol.4,pp.467-372.

9. **Du, Y.J and Wang CC (2000).**An Experimental study of the Airside performance of the superslit Fin-and-Tube Heat exchangers.Int.J.Heat mass ransfer,Vol.43,pp.4475-4482.

10. **Gray.D.L and Webb, R.L(198^)**Heat Transfer and Frictio Correlations for plate Finned-Tube Heat Exchangers having plain fins ,proceeding 8 th International journal of Heat transfer conference,Vol.6,pp.2745-2750