

# Performance of Domestic Refrigerator by Using Helical Shaped Condenser with R134a on Vapor Compression Refrigeration System

Nara Siva Balaji<sup>[1]</sup>, R. Krishna Sagar<sup>[2]</sup>, & Ede Raja Praveen<sup>[3]</sup>

Madanapalle Institute of Technology and Science, Madanapalle, AP, India <sup>[1][2]</sup>

PVP Siddhartha Institute of Technology & Science, Vijayawada, AP, India <sup>[3]</sup>

**ABSTRACT:** This project describes the analysis and design of the upright slinky shaped condenser coil performance on vapor compression refrigeration system. The machine of vapor compression is a refrigerator in which heat has been removing from the cooling chamber by evaporation of the refrigerant. The investigators mainly focus on refrigerators works on the vapor compression refrigeration system. The system having components like compressor, condenser, expansion valve, and evaporator. The system performance depends on the performance of all the components of the system. The main objective is the present work to verify the performance of a domestic refrigerator capacity using R-134a(CF<sub>3</sub>CH<sub>2</sub>F) as refrigerant, experimental set up of hermetic sealed compressor, and upright slinky shaped condenser. With these parameters' experiments are conducted on adomestic refrigerator by varying of pitchof the upright slinkyshaped condenser. It is observed that the upright slinky shaped condenser installation may give optimum results. The design of condenser main important role in the performance of a vapor compression refrigeration system. Hence experimental investigations are thebest in terms of optimization of certain design parameters are length, diameter, and pitch. In the present work an attempt is made to verify the performance of a domestic refrigerator capacity.

## I. INTRODUCTION

Vapor compression refrigeration system is a most effective type of air. The ability of a certain liquids to absorb more quantities of heat as they vaporize is the basis of this system compared to melting solids (say ice) to obtain refrigeration effect, vaporizing liquid refrigerant has more advantages when compared to other type of refrigerants. The rate of cooling can be predetermined; the vaporizing can be governed by controlling the pressure at which the liquid vaporizes. Moreover, the vapor can be immediately collected and condensed back in to liquid state so that same liquid can be recirculated repeatedly to obtain refrigeration effect. Thus, the vapor compression refrigeration system employed a liquid which evaporates and condenses immediately. The system is a closed one since the refrigerant never drains out from the system. The coefficient of performance a refrigerant system is the ratio of refrigerating effect to the compression work, therefore the coefficient of performance can be increased by increasing the refrigerating effect or by decreasing the compression work. It is a well-known fact that the spoilage of food due to bacteria growth and many other items reduces at a lower temperature. At lower temperatures, molecular motion will become slow down and the growth of bacteria that causes food spoilage also decelerates. Thus, to preserve many types of perishable food products for a longer duration, we use refrigerators in our homes, canteens, hotels, etc. The temperature of the food products must maintain at a level below that of surroundings. For this purpose, we keep the food products and beverages in a refrigerator. The volume inside of the refrigerator where we store food products, or beverages any other items is much less than the volume of the room where the refrigerator is kept. While we are keeping the food products in the refrigerator, initially they were at a higher temperature than desired temperature, meaning that it had some unwanted heat. If the heat is removed from the products, its temperature will be decreases. The refrigerator removes unwanted heat from the products which are kept inside the refrigerator and throws away that heat to the surrounding environment. As an example, let us consider a traveller traveling in a car in an Indian summer of Delhi or Kanpur. Outside temperature is very high. It is highly uncomfortable. To have a comfortable drive in the car, the temperature inside the

# International Journal of Innovative Research in Science, Engineering and Technology

(A High Impact Factor, Monthly, Peer Reviewed Journal)

Visit: [www.ijirset.com](http://www.ijirset.com)

Vol. 7, Issue 11, November 2018

car must be lowered from about 40<sup>0</sup>c to 25<sup>0</sup>c. This means that heat of the space inside of the car and its occupants must be transferred to outside. This will be done by the refrigeration unit which was fitted in the car. The volume of the car is much less than that of the surrounding area. With the rejected heat there is a significant change in the temperature inside space of the car, but no change in the temperature of the outer surroundings. And other side in many situations' environment temperatures is lower than the temperature of the space that we desire. As an example, for this consider car travel in the Winter of Delhi or Kanpur. Temperature outside is about 2-6<sup>0</sup>c for a comfortable drive with light clothing, temperature inside the car must be about 25<sup>0</sup>c. This means that heat must be supplied or pumped in to inside of the car and thus its temperature must be increased. The system that performs this operation is known as heat pump. But for different conditions such as the comfortable driving in a car that depending upon the season requires temperature to be lower or higher than the surroundings, heat must be transferred to out of the car or rejected from inside of the car. Since both the operations are performed by the same unit in the car, in a much broader sense we can say that a refrigeration unit controls the temperature of a space. In the normal refrigeration system, this is done by reversing the refrigeration cycle operation. The vapor compression refrigeration system is now a days used for all purpose refrigeration it is generally used for all industrial purpose from a small domestic refrigerator to big air – conditioning plant.

## 1.1. P-H Diagram

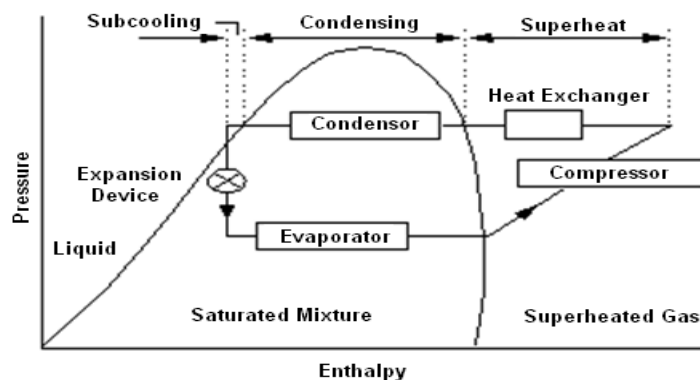


Figure 1.3. Pressure - enthalpy (p-h) chart

The most convenient chart for studying the behaviour of a refrigerant is P-H chart, in which the vertical ordinates represent pressure and horizontal ordinates represent enthalpy. A typical chart is shown figure 1.3 in which a few important lines of the complete chart are drawn. The saturated liquid line and saturated vapor line merge equal to the saturation temperature corresponding to its pressure. The left side portion of the saturated liquid line is the subcooling liquid region. The difference between liquid and vapor lines is called wet vapor region and right side of the saturated vapor line is a superheated vapor region.

## 1.2. ENERGY ANALYSIS OF REFRIGERATION

Consider a boundary enclosing a space in which refrigeration is placed. Some heat  $q_2$  given out at temperature higher than the surroundings. It is also clear that the food stuff placed inside the refrigerator is cooled by giving out their heat to the refrigerator which in turn, so to say, absorbs heat  $q_1$ , it is at lower temperature than the surroundings. Every refrigerator is supplied with energy with in the form of heat or electricity that is some work (w) is provided to it. Thus, the refrigerating device absorbing heat at lower temperature and giving out at higher temperature; this is generally not possible in our day to day life, since heat cannot flow from lower to higher temperature, but in case of a refrigerator this is obtained at the cost of energy supplied to it. For the boundary total heat output ( $q_2$ ) is equal to the total energy input in the form of heat absorbed ( $q_1$ ) and the work absorbed (e) Balancing them. For a refrigerator device, we are attentive in how much heat is extracted from food stuff and how minute electrical energy we spend, to

# International Journal of Innovative Research in Science, Engineering and Technology

(A High Impact Factor, Monthly, Peer Reviewed Journal)

Visit: [www.ijirset.com](http://www.ijirset.com)

Vol. 7, Issue 11, November 2018

minimize our power consumption. The ratio of heat absorbed to the given work input in the form of electric energy (w) is known as coefficient of performance (COP). The ratio should be as much as possible.

$$\begin{aligned} \text{COP} &= q_1/w \\ &= q_1/q_2 - q_1 \end{aligned}$$

Theoretical COP is ratio of theoretical refrigerating effect (N), found from temperature-entropy chart to the theoretical compressor work (w) or isentropic compressor work, found from the chart.

Actual COP is the ratio of actual cooling effect, to the actual energy supplied to the compressor in terms of watt-hour.

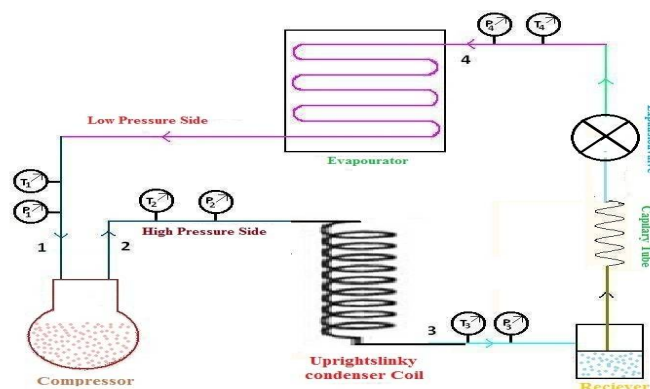
Relative COP is defined as ratio of actual COP to the theoretical COP.

### 1.3. COPPER UPRIGHT SLINKY COIL

The industrial applications for helical tubing coils range from the aerospace Industry in the refrigeration (ACR) petroleum, and industry. The choice of copper in an upright slinky condenser coil indicates that a designer is likely trying to take advantages of copper in an upright slinky coil indicates that a designer is likely trying making advantages of coppers, which is having extreme heat transfer properties –which are as much as eight times that of other materials such as aluminium. Because of the malleability of copper, it becomes viable medium for shaping the flow of liquid in such a manner to maximize whatever heat transfer outcome a designer is looking for. Whether heating or cooling, helical coils make good use of space and the use of copper itself deflates the total amount of material necessary to achieve the desired heat transfer goal. The use of copper tubing is extremely recommended if high rate of heat transfer is desired.

### 1.3. DESIGN OF UPRIGHT SLINKY COIL

The upright slinky condenser is the application for upright tubing coils ranges from copper upright slinky coil with end fixture the aerospace industry to the refrigeration (ACR), petroleum and brewing industry. In this present work remove the existing condenser and installed the upright slinky design condenser to the refrigerator (180liters) .to take the temperatures and pressure readings and calculate the performance of the system.



### 5.7. Schematic Diagram for Upright slinky Shaped Condenser of Vapor Compression Refrigeration Cycle

Diameter of design coil (D) = 540 mm  
Height of the coil (H) = 680 mm  
Number of turns (N) = 15  
Length of condenser (L) = 650 mm  
Spacing (S) = 22 mm

## International Journal of Innovative Research in Science, Engineering and Technology

(A High Impact Factor, Monthly, Peer Reviewed Journal)

Visit: [www.ijirset.com](http://www.ijirset.com)

Vol. 7, Issue 11, November 2018

Diameter width (W) = 6.35 mm

### II. PRESENT WORK

In vapor compression refrigeration system there are two heat exchangers. One is to absorb the heat from the evaporator and another is to remove heat absorbed by refrigerant in the evaporator and the heat of compression added in the compressor and condenses it back to liquid which is performed by condenser. This strategy focuses on heat rejection in the condenser this is only possible either by providing a fan cooling or by extending the surfaces. The extended surfaces are known as fins. The rate of heat rejection in the condenser depends upon the number of fins attached to the condenser surface. This concept investigated the performance of condenser using helical coiled condenser in the present domestic refrigerator and galvanized iron steel material fins are used. Here we have replaced mild steel fins of the condenser with galvanized iron steel fins. The efficiency of the condenser will also help to increase COP of the system as the sub cooling region. Incurred at the exit of the condenser. In general, domestic refrigerators we cannot arrange fans at the condenser hence extended surfaces like fins play a very vital role for the rejection of heat. To know the performance characteristics of the vapor compression refrigeration system the temperature and pressure gauges are installed at each entry and exit of the component. Experiments are conducted on up right slinky condenser having fins. Different types of tools are also used like snips to cut the plated fins to required sizes, tube cutter to the tubes and tube bender to bend the copper tube to the required angles. Thus, the domestic refrigerator is fabricated as per the design changes in condenser coil.

### III. EXPERIMENTAL SET UP

The figures show the experimental set up of the refrigerator. To know the performance characteristics of vapor compression refrigeration system the temperature and pressure gauges are installed at each entry and exit of the components. experiments are conducted on upright slinky condenser with coils spacing of the condenser on a refrigerator of capacity 180liters.all the values pressures and temperature are tabulated.



Figure 5.6. EXPERIMENTAL SETUP

Domestic refrigerator selected for the project as the following specifications:

Refrigerant used = R-134a  
Capacity of the refrigerator = 180 litres  
Compressor capacity = 0.16 H. P

# International Journal of Innovative Research in Science, Engineering and Technology

(A High Impact Factor, Monthly, Peer Reviewed Journal)

Visit: [www.ijirset.com](http://www.ijirset.com)

Vol. 7, Issue 11, November 2018

## Condenser sizes:

Length = 5.5 meter

Diameter = 6.35mm

## Evaporator's sizes

Length = 7.62 meter

Diameter = 6.4 meter

## Capillary tube sizes

Length = 2.128 meter

Diameter = 0.8 mm

## IV. EXPERIMENTAL PROCEDURE

The following procedure is adopted for experimental set up of the vapor compression refrigeration system. The chosen domestic refrigerator is working on vapor compression refrigeration cycle, Pressure gauges and temperature gauges are installed at each entry and exit of the components, the required pressure of the system is provided by pressurized nitrogen gas, R 134a is used as refrigerant in this refrigeration system by the following process the systematic line diagram for charging is shown in the figure. It is mandatory to remove the air from the refrigeration unit before charging. First the valve  $V_2$  is closed and pressure gauges  $P_2$ , vacuum gauges  $V$  are fitted as shown in the figure. The valve  $V_5$  is also closed and valves  $V_1, V_4, V_6$  and  $V_3$  are opened and the motor is started thus the air from the condenser receiver and evaporator is sucked through the valve  $V_1$  and it discharged in to atmosphere valve  $V_6$  after compressing it in the compressor the vacuum gauges  $v$  indicates sufficiently low vacuum when most of the air is removed in the system the vacuum reading should be at least 74-75 cm of hg if the vacuum is retained per above an hour it may be concluded the system is free from the air after removing the air from the system then the compressor is stopped and valves  $v_1$  and  $v_6$  are closed, the valves  $v_5, v_2$ , and  $v_7$  of the refrigerant cylinder are opened and then the compressor is started when never the sufficient quantity of refrigerant is taken in to the system which will be noted in the pressure gauges the compressor is stopped. the valves  $v_7$  and  $v_5$  are closed and valve  $v_1$  is opened the refrigerant cylinder is disconnected from the system the pressure gauges are used to note the pressure during the charging system. Leakages tests are done by using soap solution, in order to further test the condenser and evaporator pressure and check purging daily for 12 hours and found that there is no leakage which required the absolutely the present investigation to carry out further experiment. switch on the refrigerator and note the observations for 1 hour and take the pressure and temperature readings at each section. The performance of the existing system is explored with the help of temperature and pressure gauge readings. The refrigerant is discharged out and helical condenser is located at the inlet of the capillary tube. Temperatures and pressure gauge readings are taken, and the performance is investigated. The readings are tabulated for the upright slinky condenser coil. the following tests are conducted, and calculated readings are shown below.

## V. CONCLUSIONS

In the present work experiments are conducted for the upright slinky design condenser, pitch of the coil of the condenser of a vapor compression refrigeration system used for a domestic refrigerator of 180 litres capacity. The data is taken from the experimental set-up fabricated by the present investigation and is used to analyse the performance of vapor compression refrigeration system with existing condenser and with upright slinky condenser. By incorporating the upright slinky condenser of refrigerant in the system the C.O. P enhance of by 6.18%, because of 1.71% increase in refrigeration effect and 4.25% reduction in compressor work and increase in heat rejection 4.50%. It is advantageous to provide a upright slinky condenser at the inlet of the capillary tube and maintain the condenser pressure. As the performance of vapor compression refrigeration system can be enhanced with the help of the upright slinky condenser. Further, at the condenser pressure increased between the condenser and evaporator, the combination of existing and upright slinky provided increase in C.O.P compared to existing condenser, which is perhaps due to reduction in heat loss by existing condenser.

# International Journal of Innovative Research in Science, Engineering and Technology

(A High Impact Factor, Monthly, Peer Reviewed Journal)

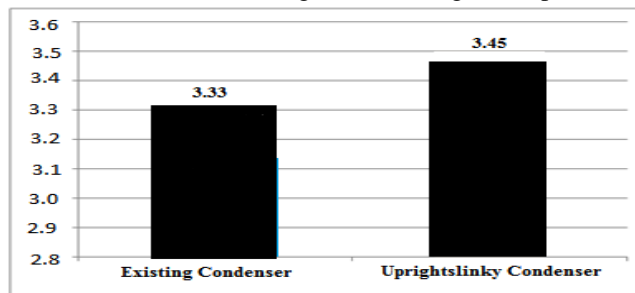
Visit: [www.ijirset.com](http://www.ijirset.com)

Vol. 7, Issue 11, November 2018

The performance of vapor compression refrigeration cycle considerably the upright slinky condenser with the existing condenser and pitch of the coil varies the condenser has the considerable effect. To illustrate these effects the calculated values of upright slinky condenser and pitch of the coil have been plotted on graphs. The Graph plotted between existing refrigerator COP and experimental Set up COP

S. No	Existing Refrigerator COP	Experimental setup COP
1	3.33	3.45

Table 5.1 Tabular column of refrigerator existing and experimental COP



Graph 5.2 Existing Condenser COP Vs upright slinky condenser COP

## REFERENCES

- [1] Akintunde, M.A. 2004b. Experimental evaluation of the performance of Vapor Compression Refrigeration Systems. Federal University of Technology, Akure, Nigeria.
- [2] Eckert, E.R.G.; Goldstein, R.J.; Ibele, W.E.; Patankar, S.V.; Simon, T.W.; Strykowski, P.J.; Tamma, K.K.; Kuehn, T.H.; Bar-Cohen, A.; Heberlein, J.V.R.; (Sep 1997), Heat transfer--a review of 1994 literature, International Journal of Heat and Mass Transfer 40-16, 3729-3804.
- [3] [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 Azzouz, K.; Leducq, D.; Gobin, D.
- [4] Akintunde, M.A. 2004b. Experimental evaluation of the performance of Vapor Compression Refrigeration Systems. Federal University of Technology, Akure, Nigeria.
- [5] Kays WM, London AL. Compact heat exchangers. New-York: McGraw-Hill, 1984.
- [6] 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.
- [7] Refrigeration and Air Conditioning by S.C. ARORA and DOMKUNDWAR Fourth edition pages (13.47-13.49).
- [8] C.P Kodandaraman of Second edition by Fundamentals of Heat and Mass Transfer
- [9] BY JAMES R. LINES. Upright slinky Coiled Heat Exchangers offer Advantages GRAHAM MANUFACTURING CO. INC.
- [10] [HTTP: WWW.CHANGPUAK.CH/ELECTRONICS\CALC\\_21.PHP](http://WWW.CHANGPUAK.CH/ELECTRONICS\CALC_21.PHP)  
The Continental united states from Buchanan  
[MI49107,improvement@coppertubecoils.com](mailto:MI49107,improvement@coppertubecoils.com)