EVALUVATION OF REFRIGERATOR BY THE INCLINED ARRANGEMENT OF FINS OVER THE CONDENSER

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Abstract:

This experiment set up reports about the performance of a VCRS with inclined arrangement of fins over the condenser by using R134a as refrigerant. Most of the refrigerators work on VCRS systems. The VCRS system consists of main components like Compressor, Condenser, Expansion valve, and Evaporator.

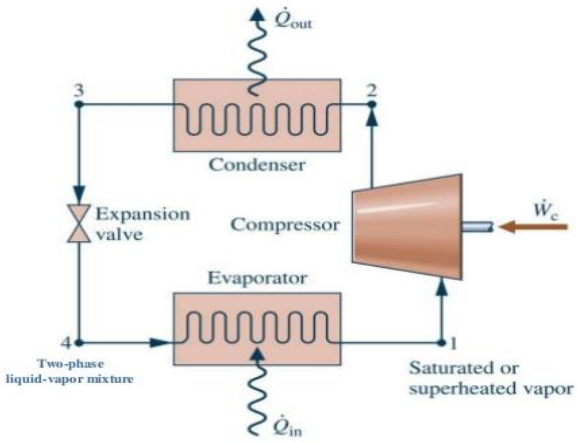
The main motive of this project includes to evaluate the cooling capacity (or) refrigerating effect & COP of the system by arranging the fins in inclined manner over the condenser on one side of the refrigerator. In this experiment the spacing between the fins will be reduced, by this the heat removal rate is increased and performance of the system will be improved.

Keywords: Vapor Compression Refrigeration System (VCRS), Coefficient of Performance (COP), Heat removal rate, refrigerating effect.

1.INTRODUCTION:

Condenser and evaporators are basically heat exchangers in which the refrigerant undergoes a phase change. Generally copper tubes are used because of its excellent heat transfer ability. The condensers with steel tubes are used in ammonia refrigerating systems. Majority of the domestic refrigerators uses the natural convection air cooled condenser. In the present work refrigerator uses the natural convection air cooled condenser. In natural convection air cooled condenser, the heat transfer from the condenser coils to the air is by natural convection. As the air comes in contact with the warm condenser tubes, it absorbs heat from the refrigerant and thus the temperature of air increases. The warm air being lighter, rises up and cold air from below rises to take away the heat from the condenser. This cycle continues in natural convection air cooled condensers. This paper is an experimental approach to increase the heat to be rejected in the condenser as well as increase the performance of the system. If the condenser is having more fins spacing then the number of fins available at the condenser are less. Due to this surface area decreases. Therefore less heat transfer occurs. On the other hand if the condenser is having less fins spacing then the number of fins available at the condenser are more. Therefore more heat rejection takes place in the condenser. Because of more heat rejection sub cooling occurs at the exit of the condenser which in turn increases the performance of the system.

Schematic Diagram of VCR Cycle



OBJECTIVE:

The main objective of the present experimental work is

- To determine the performance of the system with and without load conditions.
- To compare the existing system with the proposed system i.e., inclined arrangement of fins over the condenser.

COMPONENTS USED:

- Domestic Refrigerator of 165 liters Capacity consists of Hermetically Sealed Compressor, Condenser, Capillary tube, Evaporator
- Copper tube
- Fin
- Thermocouples
- Stop watch
- Pressure gauges
- R-134a Refrigerant
- Base Stand
- Power Supply(230V AC, 50 Hz)

SYSTEM DESCRIPTION:

The Domestic Refrigerator, which is used for the current Experimental work has the specifications of

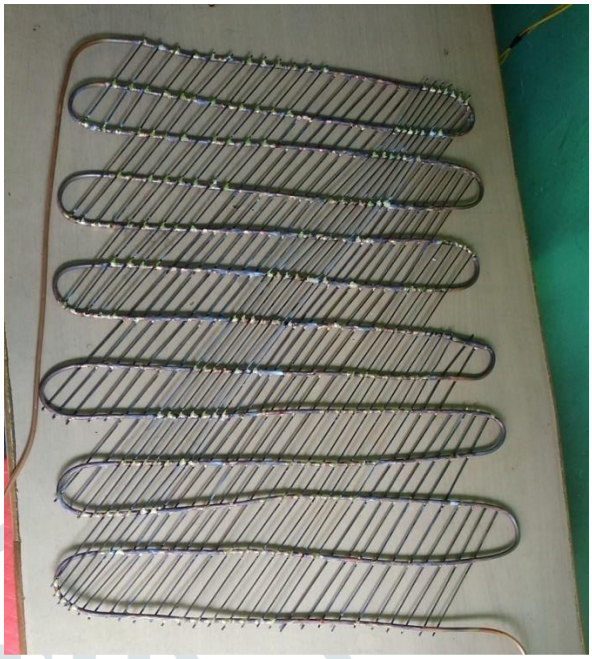
1. Refrigerant used : R-134a (Tetrafluoro-ethane)
2. Refrigerator Capacity : 165 liters
3. Compressor Capacity : 1/6 HP
4. Condenser Sizes
   - Length : 9.35m
   - Diameter : 4.76mm
5. Capillary tube
   - Length : 2.48m
   - Diameter : 0.8mm
6. Evaporator
   - Length : 7.62m
   - Diameter : 6.4mm
7. Fins (copper material)
   - Length : 0.7m
   - Diameter : 2mm

HEAT EXCHANGERS:

CONDENSER:

The main purpose of Condenser is to reject the heat from the refrigerant to the Surroundings by removing excess heat through the process of Condensation of refrigerant. The amount of heat rejected is given by Q= UA (LMTD) U is the overall convective heat transfer Coefficient, A is the Surface area (m2), LMTD: logarithmic mean temperature difference between the temperature of refrigerant and Surroundings (OC)

In Domestic Refrigerators, the Condenser is made up of Iron and has a thermal Conductivity of 79.5W/mK and the Emissivity Coefficient is 0.14-0.38.In this Current Experimental work, the condenser is made up of Copper and has a thermal Conductivity of 385W/mK and the Emissivity coefficient is 0.023-0.052. Fins are arranged in inclined (Diagonally 45℃) manner with a spacing of 6mm a part. By this arrangement discharge pressure will be increased, with this coefficient of performance of the systems will be increased.



VERTICAL ARRANGEMENT OF FINS OVER THE CONDENSER

INCLINED ARRANGEMENT OF FINS OVER THE CONDENSER

EVAPORATOR:

The evaporators are heat exchanger surfaces that transfer the heat from the substance to be cooled to the refrigerant, thus removing the heat from the substance. The evaporators are used for wide variety of diverse applications in refrigeration and air conditioning processes and hence they are available in wide variety of shapes, sizes and designs.

In the evaporator the refrigerant enters at very low pressure and temperature after passing through the expansion valve. This refrigerant absorbs the heat from the substance that is to be cooled so the refrigerant gets heated while the substance gets cooled. Even after cooling the substance the temperature of the refrigerant leaving the evaporator is less the than the substance. The refrigerant leaves the evaporator in vapor state, mostly superheated and is absorbed by the compressor.

REFRIGERANT (TETRA-FLOURO ETHANE):

The Refrigerant which is used in the Present Research work is R-134a, which is commonly known as Tetra-flouro Ethane. It belongs to Hydro Carbon Family and is widely used Refrigerant. It is non-toxic, non-flammable, non-explosive, highly affinity of moisture, immiscible in mineral oils, highly hygroscopic and has a good chemical stability.

Fig: R-134a (Tetra-flouro Ethane) Refrigerant Cylinder

Table: Properties of R-134a Refrigerant

S.NO	PROPERTIES OF REFRIGERANT	VALUE
1	Name	Tetra fluoro ethane
2	Chemical Formula	CH_2CF_3
3	Group	HFC
4	Atmospheric Life	16
5	Cylinder Colour	Light Blue
6	ASHRAE Safety Rating	A1
7	Ozone Depletion Potential(ODP)	0
8	Global Warming Potential(GWP)	1300
9	Type of Availability	Pure form or blended
10	Ratio of Specific heat of Refrigerant at constant pressure to Constant volume(C_p/ C_v)	1.31
11	Critical Temperature (T_{cr})	$101.06^{O}C$
12	Normal Boiling Point	$-26.15^{O}C$
13	h_{fg} at Normal Boiling Point	222.5 KJ/Kg
14	Pressure at Room Temperature	70 psi
15	Auto Ignition Temperature	$770^{O}C$
16	Solubility in water	0.11% by weight at $25^{O}C$

APPLICATIONS OF R-134A:

- It is used as a replacement of R-12 Refrigerant in Domestic Refrigerators.
- It is widely used in water coolers, Air Conditioning Systems, Automobile A/C's and etc.

DISADVANTAGES:

According to Montreal Protocol, the refrigerants belongs to HFCs should be phase out by 2030 and according to Kyoto Protocol, phase out the Substances that lead to Global warming by 2030. Since R-134a belongs to HFCs, it will fade out by 2030.

2. EXPERIMENTAL WORK:

The Copper coil of required dimensions is taken and bend the coil in to normal condenser shape. Fins of required material was taken and arrange them in inclined manner i.e., diagonally with 45℃ . The spacing between the fins was 6mm. Leakage tests are to be done by using soap solution. Take the Domestic Refrigerator and fit the proposed system i.e., inclined arrangement of fins over the condenser with the help of tools like tube cutter, cutting plier, flaring bar, nose plier, Ratchet. Install the Pressure gauges and temperature indicators i.e., thermocouples at each entry and exit of the Component.

Once the system has no leakages, Charge vacuums in to the refrigerator in order to make the system stable. Now Charge the refrigerant R-134a along with anti-choke in order to remove the moisture present in the Compressor. Charge the refrigerator up to which it is about to gets the back pressure. Take the readings of pressure and temperature of the Components for both the Existing and Proposed System for load and unload Conditions separately. Calculate for the Performance Parameters with the help of the readings.

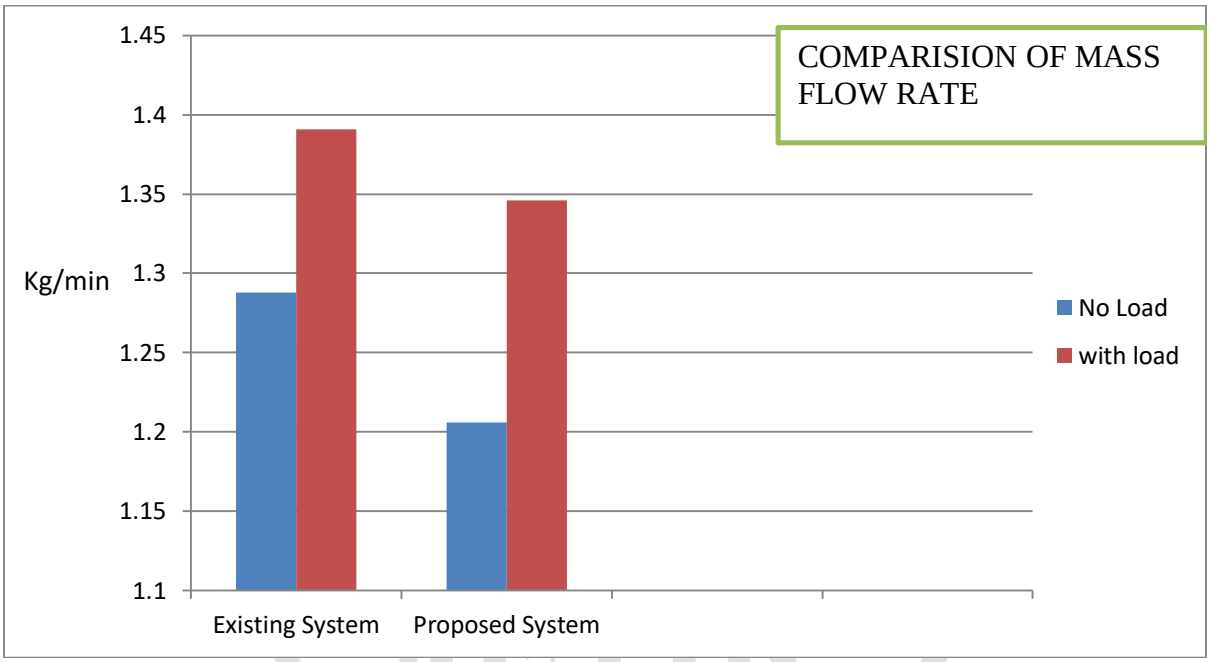

3.RESULTS AND DISCUSSION:

Performance comparison of inclined and vertical arrangements with load Conditions

S. No.	Parameters	Vertical arrangement	Inclined arrangement
1	Net Refrigeration Effect in KJ/Kg	151	156
2	Coefficient of Performance	2.79	3.05
3	Mass flow rate to obtain 1TR kg/min	1.3907	1.346
4	Work of compressor in KJ/Kg	54	51
5	Power consumption in KW	1.251	1.1441
6	Heat rejection in the condenser in KJ/Kg	205	207
7	Heat equivalent of work compression per TR kJ/min	75.0978	68.646
8	Compressor pressure ratio	8.5058	9.6035

The Performance Parameters for VCR System have been calculated for both load and unload conditions. The following are the Results that have been compared for both the Existing and Proposed Systems in both load and un load Conditions.

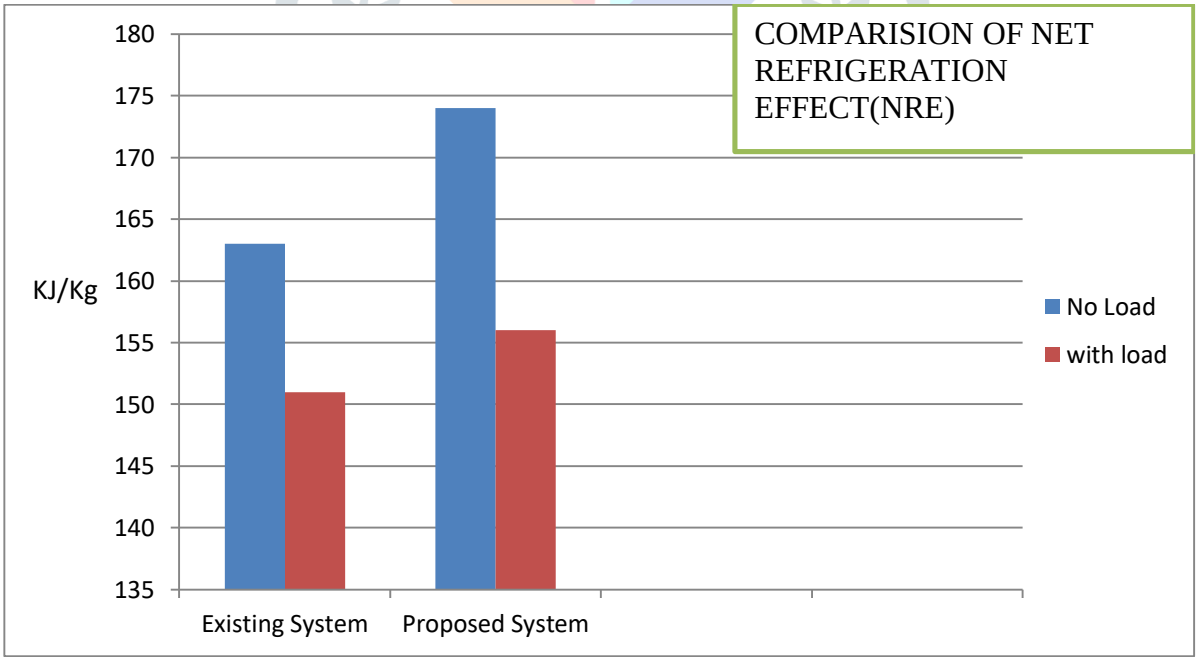
COMPARISON OF MASS FLOW RATE:



Comparision of Mass flow rates

From the above results, it is to be noted that the Mass flow rate of the Proposed System has been reduced to 10.40 % from 1.346 Kg/min to 1.206 Kg/min.

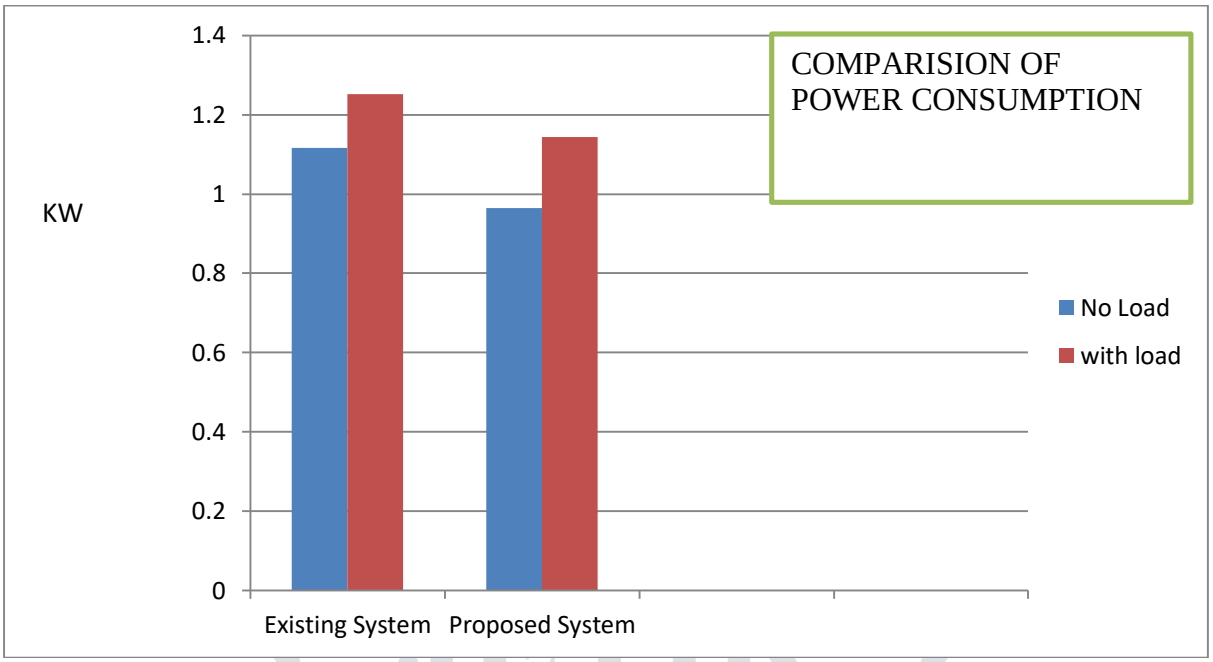
COMPARISON OF NET REFRIGERATION EFFECT:



Comparison of Net Refrigeration Effect

It is obvious from the above result that the Net Refrigeration Effect of the proposed system has been increased to 11.53 % from 156 KJ/Kg to 174 KJ/Kg due to the change in shape of the Condenser.

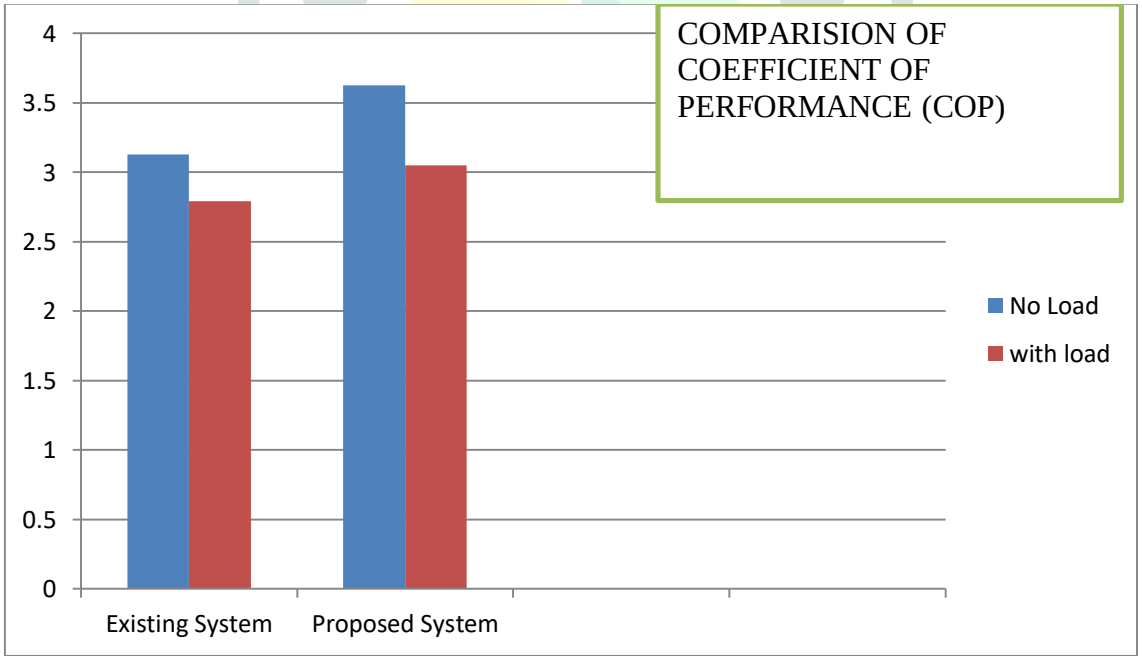
COMPARISON OF POWER CONSUMPTION:



Comparison of Power Consumption

It is clear from the above result that proposed system the Power Consumption of the Compressor has been reduced to 18.58 % from 0.9648 KW to 1.1441 KW.

COMPARISON OF COEFFICIENT OF PERFORMANCE (COP):



Comparison of Coefficient of Performance (COP)

From the above result, it is shown that the Coefficient of Performance (COP) of the Proposed System has been increased to 15.86 % from 3.625 to 3.05.

4.CONCLUSIONS:

From the above results,

- It is concluded finally that, by changing the arrangement of fins on Existing and Proposed Systems the coefficient of performance will give better performances than the Normal Iron Condenser.
- In the Proposed System, the Net Refrigeration Effect is increased to 11.53 %, Power Consumption reduces to 18.58 %, Heat rejection is increased by 6.75 %, mass flow rate reduces to 10.40 %, COP increases to 15.86 %.

5. ACKNOWLEDGEMENTS:

I am greatly thankful and forever indebted to my guide Dr.M.Yohan for his valuable suggestions, motivation and inputs while undertaking this work. I would like to extend my thankfulness to the Head Of the Mechanical Engineering Department Dr. B. Chandra Mohan Reddy for his encouragement. I would like to thank my friends for their constant support and motivation in writing this journal. I am grateful to all the Professors and lecturers of Refrigeration and air conditioning, JNTUA College of Engineering (Autonomous), Ananthapuram, Andhra Pradesh, India.

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