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EXPERIMENTAL ANALYSIS OF VCRS WITH TAPERED COIL CONDENSER USING HYDRO CARBON AS REFRIGERANT

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ABSTRACT:
Generally the domestic VCRS system uses bare tube as condenser, but with this the heat transfer rate is not up to the optimum level.For achieving better heat transfer rates different shapes and geometry of tubes can be used.one of this is the coil condenser .
A coil condenser is preferred in many applications due to its compact structure, larger heat transfer area and higher heat transfer capability. To make it more effective a tapered coil condenser is used. Several researches have also indicated that heat transfer rate in coiled tube are superior to straight tube due to complex flow pattern exist inside coil pipe. The concept behind compact heat exchanger is to decrease size and increase heat load which is the feature of coil heat exchanger.
Though refrigerant R-134a is better in performance, it is an hydro fluoro carbon which has more global warming potential and ozone depletion potential. So, it is not fit for future use, therefore there is a need for alternative refrigerant. The alternative can be hydrocarbons (R600a-iso butane, R290-propane,R600-butane and mixture of R290&R600 etc.)
In this research work a 180L capacity refrigerator equipped with tapered coil condenser working on hydro carbon is analysed. Finally it is observed that the COP of the tapered coil condenser coil refrigerator is more while comparing with the existing system.
The performance parameters such as refrigerating effect, mass flow rate, compressor work and coefficient of performance are calculated. Finally the performances of both the existing system and proposed system are compared.

Keywords: taperedcoil,hydrocarbons, mass flow rate, coefficient of performance.

1. INRTODUCTION:

Most of the domestic refrigerators are operate on VCR system and run for usual C.O.P. which pays attention to intensify the cop with some alternations made on the components assembled in the system. Fig shows the simplified diagram of components of a VCR system.

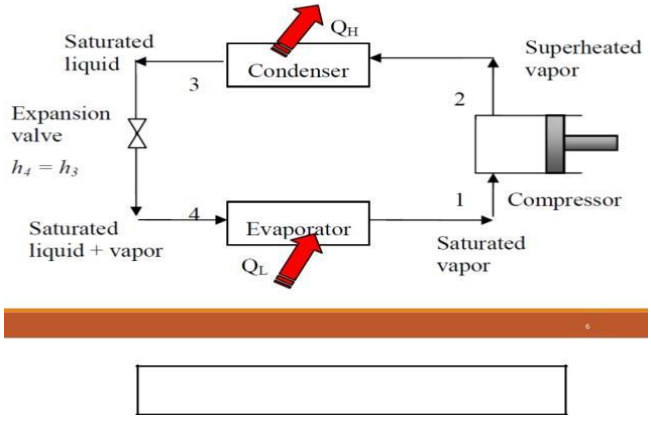

Fig1.1 Outline of VCR

In the thermodynamic cycle the refrigerant such as R134 a in vapour state enters into the compressor .The vapour refrigerant is compressed into the hermetically sealed compressor to high pressure and high temperature at constant entropy. Then this high pressure and high temperature gaseous refrigerant sent into the condenser coil and condenses into a liquid from vapour state by removing extra heat at constant pressure and temperature. After that the liquid refrigerant passes through the expansion valve, where its pressure diminishes suddenly. Finally it is sent into the evaporator coil at

low pressure and low temperature liquid refrigerant absorbs the heat present in the evaporator and transforms into vapour form, with this one cycle completes. Now again the refrigerant sent into the compressor then starts the new cycle.

There are two methods to intensify the heat transfer rate. Those include 1.Active methods and 2.Passive methods.

Active Methods:
Active methods are those which need external power source to ensure the enhancement.
Examples of the active methods includes fan providing on the condenser coil for rapid cooling, sprays and jet impingement etc

Passive Methods:
Passive methods are those which doesn't need external power source to ensure the enhancement mechanism.
Examples of the passive methods includes Smooth surfaces ,rough surfaces, twisted tape inserts, helical inserts, displacement enhancement appliances ,coiled wires ,ribs ,baffles and winglets.

In this research work one of the passive method i.e., tapered coil is used to intensify the heat transfer rate. Hence the tapered coil do require additional power source to enhance the heat transfer rate. It can create swirl flow to the flowing fluid. This decrease the hydraulic diameter of the flow passage. This swirl flow in turn intensifies the temperature difference with the surrounding which finally leads to a high heat transfer coefficient.

2.Objectives:

The main objectives of this work are as follows:

1. To create test setup by modifying VCRS with tapered coil condenser in place of bare tube condenser and hydro carbon as refrigerant.
2. To evaluate the performance of VCRS system with tapered coil condenser by using hydrocarbon as refrigerant.

3. Experimental Work:

The condenser is one of the most important components of VCRS system which contributes a lot in the overall performance. Effectiveness of its working through rigged control taken over various performances affecting attributes correlate to it, delivers the worth accepted results at minimum possible cost expenditure. As function of the condenser is dissipating the heat absorbed by the refrigerant during the evaporation process and comparison. The refrigerant cop is the function of its operating temperature, the current work under takes modification of condenser geometry and thus the temperature gradient with the surrounding regulation maintained system cop would be high.

This research work is concentric about tapered coil condenser vcrs system using hydro carbon refrigerant holding 180 litres capacity.

Fig: Tapered Coil

The tapered coil condenser is the coil condenser which is not uniform in diameter,the coil is twisted so as to form one end greater in dia meter than the other. In conventional VCRS, iron is used as condenser material which is having less thermal conductivity (79.5W/m.k). High power consumption and have a chance of corrosion. As an alternative to Iron material copper is used which is having thermal conductivity (385 W/mk) and corrosive resistive compared to Iron. The copper coil is twisted to form an outer diameter of 75mm and an inner diameter of 17.5mm and taper length of 575mm and an taper of 1/10 and an taper angle of 5.71. Here the heat transfer area is increased by making the condenser in tapered coil shape.

Hydro Carbon Refrigerant:

In this research work we are using hydrocarbon as the refrigerant the hydrocarbons are organic compounds which are successfully used as refrigerants in industrial and commercial installations. Most of them possess satisfactory thermodynamic properties but are highly flammable. They have Zero ozone depletion potential and negligible global warming potential. They are non-toxic, Hydro carbon mixtures are much lighter and can extend component life significantly. They are cheap universal refrigerant and totally compatible with all known equipment and oils used in refrigeration and have no negative reaction to moisture in the system.

Fig : Hydro Carbon Refrigerant

EXPERIMENTAL SETUP:

The domestic refrigerator selected for the research work has the following specifications:

Refrigerant used		:Hydrocarbon
Capacity of the Refrigerator		:180 litres
Compressor Capacity		:0.14H.P.
Condenser sizes		
Length	-8.5 m	
Diameter	-6.35mm	
Evaporator		
Length	-7.62 m	
Diameter	-6.4mm	
Capillary		
Length	-2.428m	
Diameter	-0.8mm	

Specifications of tapered coil condenser:

Tube Diameter	-	4.76mm
Outer diameter of Coil	-	75mm
Inner Diameter of Coil	-	17.5mm
No of Turns	-	27
Length of the Coil	-	10.36m
Taper length	-	575mm
Taper	-	1/10
Taper Angle	-	5.710deg

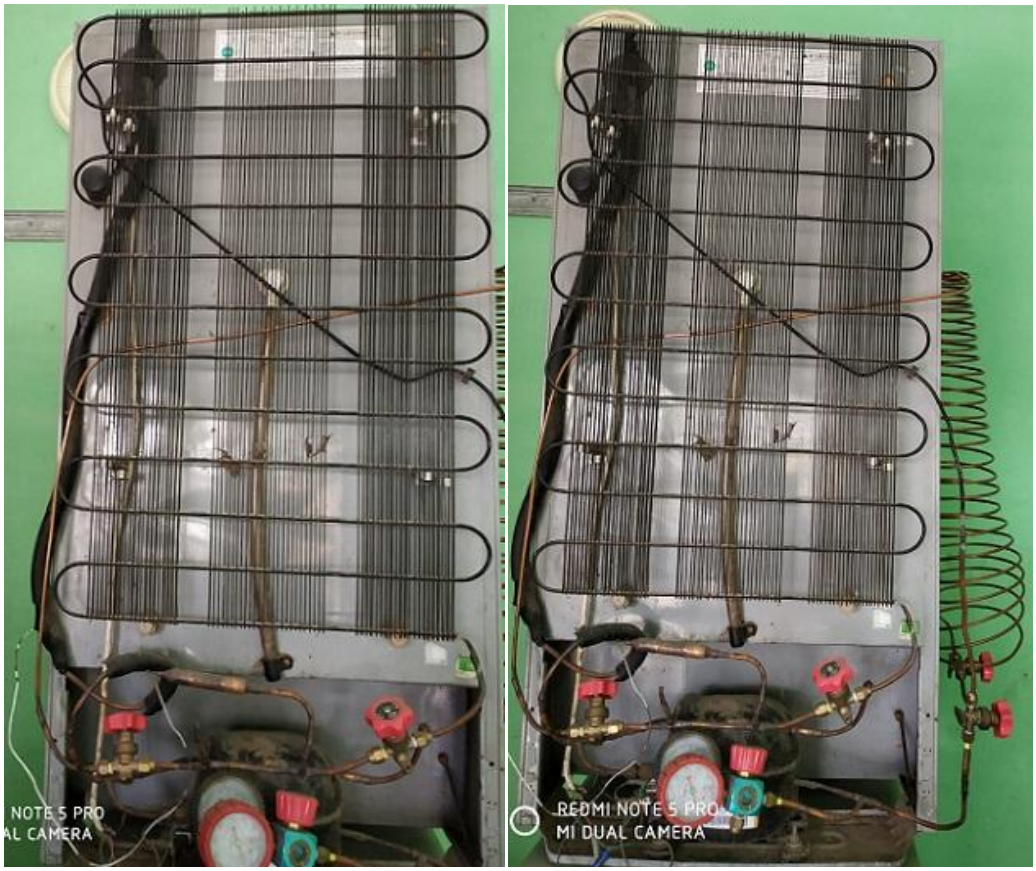

Fig : Experimental setup

4. EXPERIMENTAL PROCEDURE:

The following procedure is adopted for experimental setup of VCR system.

1. The domestic refrigerator working on VCR system (R134 a) and having capacity 180 litres is taken.
2. Pressure and temperature gauges are installed at each entry and exit of the components. Along with this one thermocouple is placed at the evaporator and tapered coil condenser is connected to the system via bypass valves.
3. Flashing of the system is done by pressurised nitrogen gas.
4. The refrigerant R-134a is discharged out of the system and hydrocarbon is charged into the system.
5. Leakage tests are done by using soap solution, in order to further test the condenser and evaporator pressure and check purging for 12 hours and found that there is no leakage which required absolutely the present investigation to carry out further experiment.
6. The refrigerator is turned on and the pressure and temperature readings for every 5 minutes are taken, continued upto one hour and then turned off.
7. By using these temperature and pressure gauge readings the performance of the existing system is found out.
8. Now the bypass valve is turned on so as to connect the tapered coil condenser to the system, this now acts as the condenser .
9. The the sysem turned on and the temperature and pressure gauge readings are taken and then calculate the performance by using these values. Then compare the performance parameters for both the systems.

Comparison of Performance parameters for Existing and Proposed systems.

S.No.	Parameter	Existing System	Proposed System
1	Net Refrigerating Effect	172	186
2	Coefficient of Performance	3.51	3.95
3	Mass flow rate to obtain 1 T.R. kg/min	1.2209	1.1290
4	Work of the compressor in KJ/Kg	49	47
5	Power consumption in KW	1.26	1.198
6	Heat to be rejected in condenser in KJ/Kg	221	233

5. RESULTS AND DESCUSSIONS:

Various performance parameters for both existing and proposed system are calculated and compare as shown below.

Comparison of Coefficient of Performance:

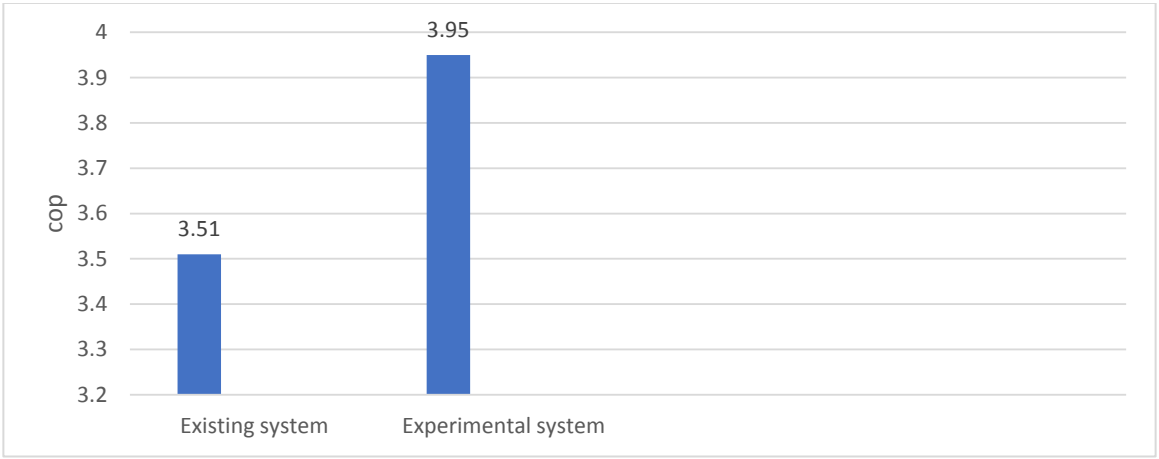

Fig: 5.1 Comparison of cop

The above figure shows the cop of both existing and proposed system. By using this graph it is clearly noticed that the proposed system has higher cop than existing one.
The COP is increased by 12.85% from 3.51 to 3.95. By introducing the tapered coil condenser the thermal boundary layer thickness increases then heat transfer rate increase which intern leads to enhancement of cop.

Comparison of Net Refrigerating Effect:

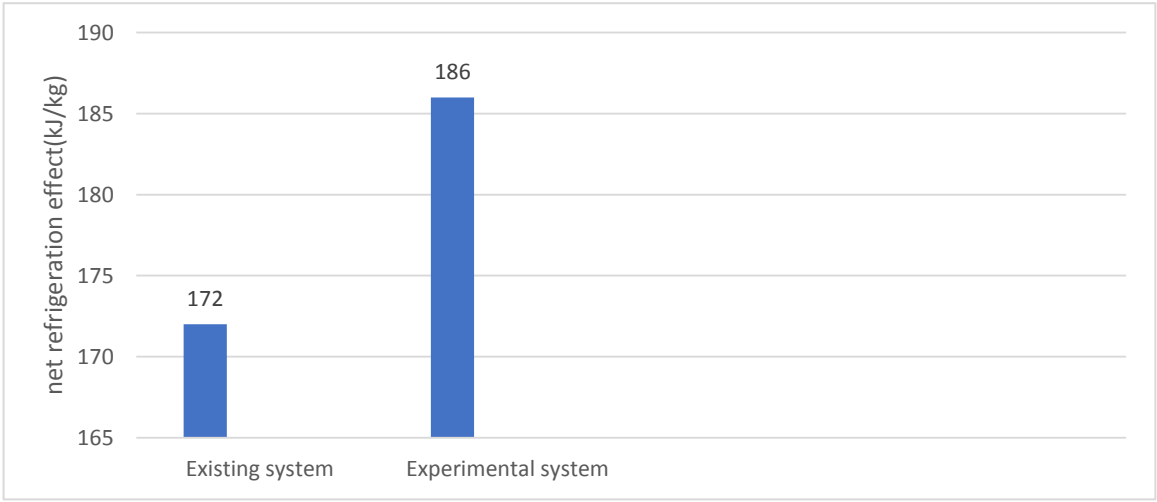

Fig:5.2 Comparison of Net Refrigerating Effect

The above fig shows that the NRE of both existing and proposed system .By using this it is clearly noticed that the proposed system has the high NRE than existing one. The Net Refrigerating Effect is increased by 8.1% from 172 to 186KJ/Kg. Due to swirl flow by the tapered coil the heat rejection ratio increases which leads to intensify the Net Refrigerating Effect.

Comparison of Mass flow rate:

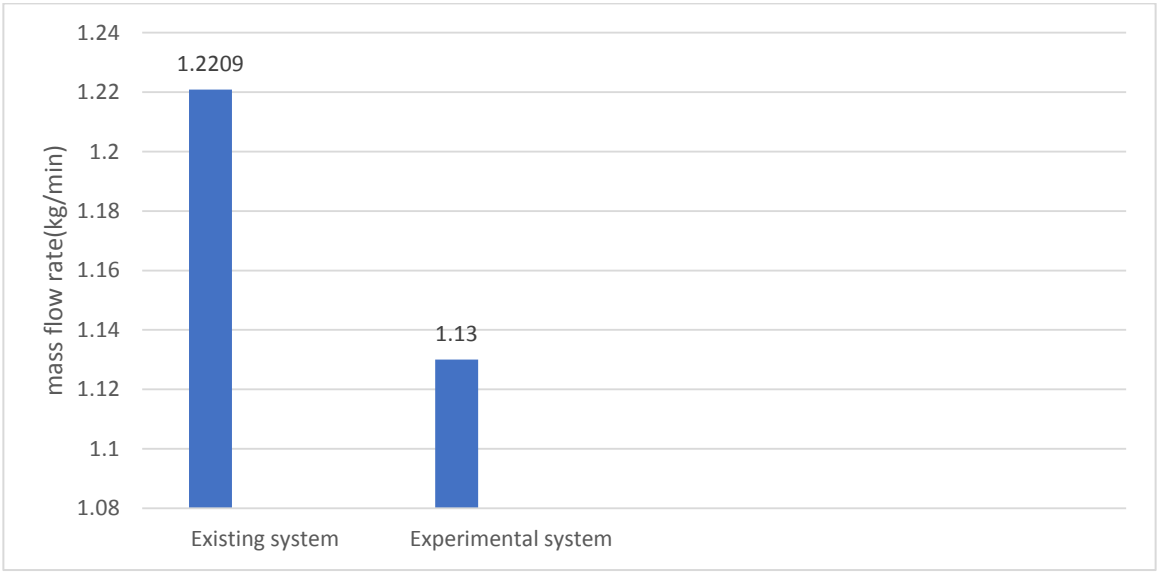

Fig:5.3 Comparison of Mass flow rate

From the above fig it is clearly noticed that the proposed system has less mass flow rate while compare to existing one. The mass flow rate is decreased by 7.37% from 1.22 to 1.129Kg/min.

Comparison of power consumption:

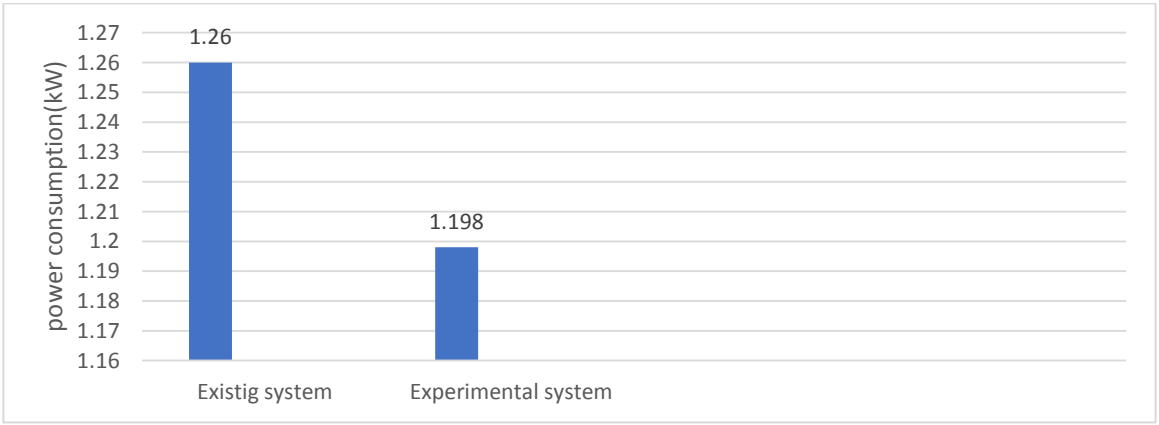

Fig:5.4 Comparison of Power consumption

From the graph it is clearly noticed that the power required for proposed system is less than the existing system. The power consumption is decreased by 4.92% from 1.26 to 1.19 KW.As the compressor work decreases in the proposed system, hence the power required is diminishing

6. CONCLUSION:

The performance of the refrigeration system is increased by introducing the tapered coil condenser coil. High heat rejection through the condenser helped to increase COP. The use of hydrocarbon as refrigerant given best results, so it can be prominient alternative for R-134a.
In the experimental system the cop is increased by 12.85%, Refrigerating Effect is increased by 8.1%, Power Consumption is diminished by 4.92%, Work done by the compressor is diminished by 4.08% and Heat rejection is increased by 5.42%.

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