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[Jhansi, 5(10): October 2018] ISSN 2348 – 8034
DOI- 10.5281/zenodo.1462669 Impact Factor- 5.070

GLOBAL JOURNAL OF ENGINEERING SCIENCE AND RESEARCHES

PERFORMANCE ANALYSIS OF VCR SYSTEM WITH TWISTED TAPE CONDENSER BY USING R134a REFRIGERANT

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Abstract

This research work reports on the performance analysis of a vapour compression refrigeration system with twisted taped condenser by using R134 as refrigerant. Majority of the refrigerators today works on the VCR system. This system consists of the following important components, compressor, condenser, expansion valve and evaporator.

The accomplishment of the system depends upon the all the parts of the system. The main purpose of this research work is to intensify the heat transfer rate through the condenser coil by inserting the twisted tapes into the condenser coil .The twisted tapes with twisting ratio (y/d=2.134) is used. In this research work two twisted tapes one with Al and another one with Cu are separately inserted into the condenser coils and the performances of both the coils compared with the existing system. Twisted tape is a type of vertex generator which can give the swirl flow to the fluid, due to this the temperature difference of the fluid with the surroundings increases, which can finally results to a high heat transfer coefficient. Finally it is observed that the COP of the twisted taped 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 for both Cu and Al twisted tapes are compared

Keywords: *Heat transfer intensification, twisted tape, swirl flow, mass flow rate, coefficient of performance and twisting ratio.*

I. INTRODUCTION

Most of the domestic refrigerators are operate on vapour compression refrigeration systems 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.

ISSN 2348 – 8034
Impact Factor- 5.070

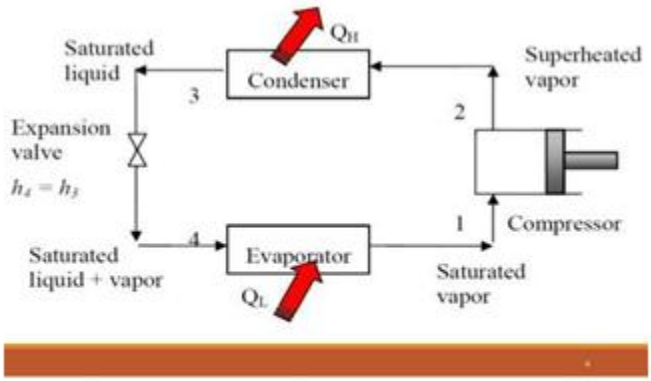

Fig1.1 Outline of VCR

In the thermodynamic cycle the refrigerant such as R-134a 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 Active methods and Passive methods.

Active Methods
Active methods are those which need external power source to ensure the enhancement mechanism. 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. twisted tape is used to intensify the heat transfer rate. Hence the twisted tape doesn't require additional power source to enhance the heat transfer rate. It can create swirl flow to the flowing fluid. These twisted tapes decrease the hydraulic diameter of the flow passage. This flow blockage increases the velocity of flow and sometimes it gives the secondary flow.

This secondary flow further adds better thermal contact between surface and the fluid because this flow generates the swirl flow and intensifies the temperature difference with the surrounding which finally leads to a high heat transfer coefficient.

II. 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 is 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 twisted tapes inserted into the condenser coil of refrigerator (R134 a) holding 165 liters capacity.

Fig: 2.1 Twisted Tapes

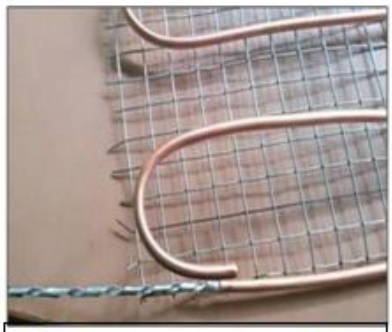

Fig: 2.2 Condenser Coil Making

Fig: 2.3 Insertion of the twisted tape into the condenser coil

Twisted tapes are the metallic strips twisted using some of the suitable methods as per the required shape and dimension, which are inserted in the flow to enhance the heat transfer rate. The twisted tape inserts are most suitable and widely used techniques to enhance the H.T. rate.

The heat transfer enhancement of twisted tape inserts depends on the pitch and twist ratio.

Experimental setup

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

Refrigerant used	: R -134a
Capacity of the Refrigerator	: 165 liters
Compressor Capacity	: 0.16H.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 twisted taped condenser:

Diameter	- 8.8mm
Length	- 36ft
No of turns	- 13

ISSN 2348 – 8034
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Twisting ratio - 2.134

Angle of twist - 180^{0}

Fig:2.4 Refrigerator with Twisted taped Condenser

III. EXPERIMENTAL PROCEDURE

The following procedure is adopted for experimental setup of VCR system. The domestic refrigerator working on VCR system (R-134 a) and having capacity of 165 liters is taken. Pressure and temperature gauges are installed at each entry and exit of the components. Along with this one thermocouple is placed at the evaporator. Flashing of the system is done by pressurized nitrogen gas. R- 134 a refrigerant is charged into the VCR system. 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.

The refrigerator is switched on and observation is required nearly for 50 to 60 min and take the pressure and temperature readings at each section. By using these temperature and pressure gauge readings the performance of the existing system is found out.

The refrigerant is discharged out and twisted taped condenser coil is placed between the compressor and capillary tube. 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.

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Table 1: Comparison of performance parameters for existing and proposed systems

S.No.	Parameter	Existing System	Proposed System
1	Net Refrigerating Effect	180	198
2	Coefficient of Performance	2.76	3.19
3	Mass flow rate to obtain 1 T.R. kg/min	1.167	1.15
4	Work of the compressor in KJ/Kg	65	62
5	Power consumption in KW	1.26	1.198
6	Heat to be rejected in condenser in KJ/Kg	245	275.75

IV. RESULTS AND DISCUSSIONS

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

Comparison of Coefficient of Performance:

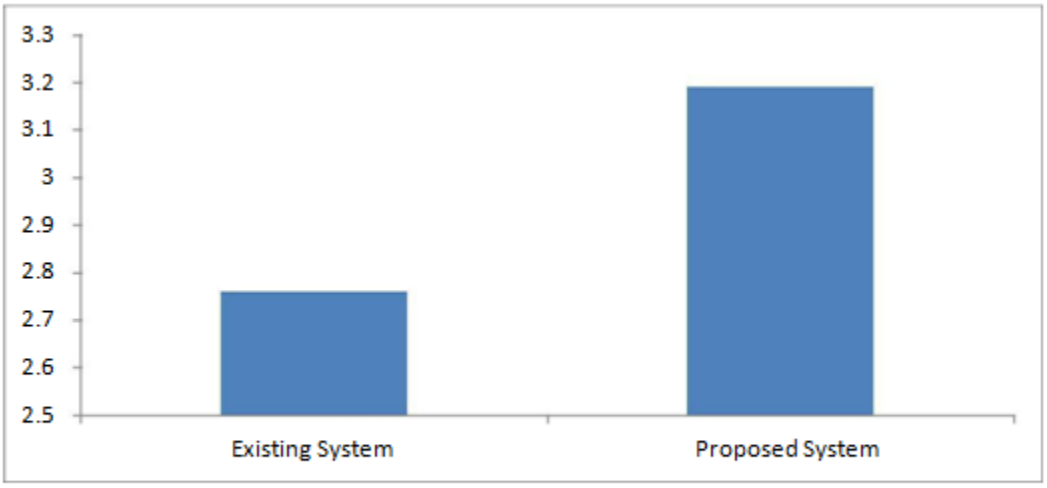

Fig: 4.1 Comparison of COP

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 15.57% from 2.76 to 3.19. By introducing these twisted tapes the thermal boundary layer thickness increases then heat transfer rate increase which intern leads to enhance the COP.

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Comparison of Net Refrigerating Effect:

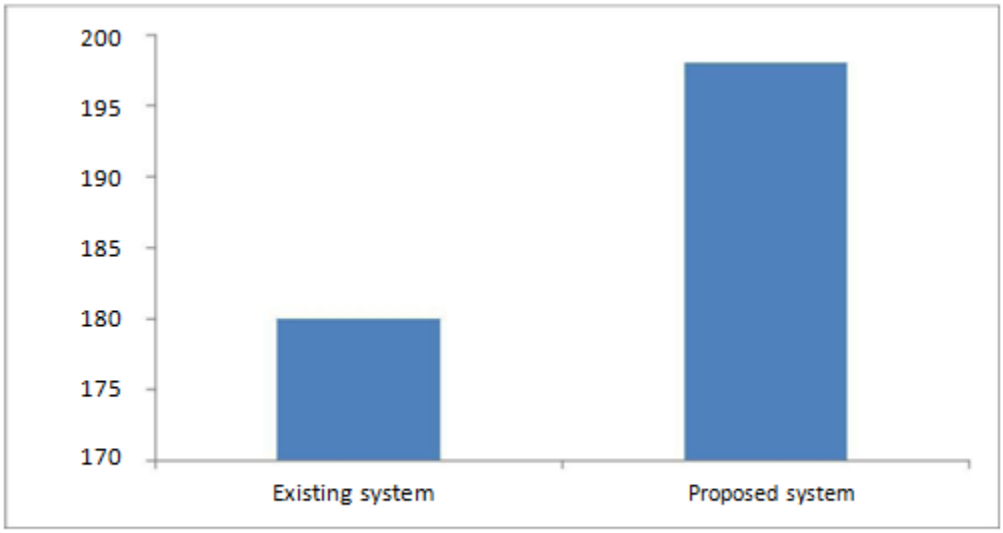

Fig: 4.2 Comparison of Net Refrigerating Effect

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 10% from 180 to 198 KJ/Kg. Due to swirl flow by the twisted tapes the heat rejection ratio increases which leads to intensify the Net Refrigerating Effect.

Comparison of Mass flow rate:

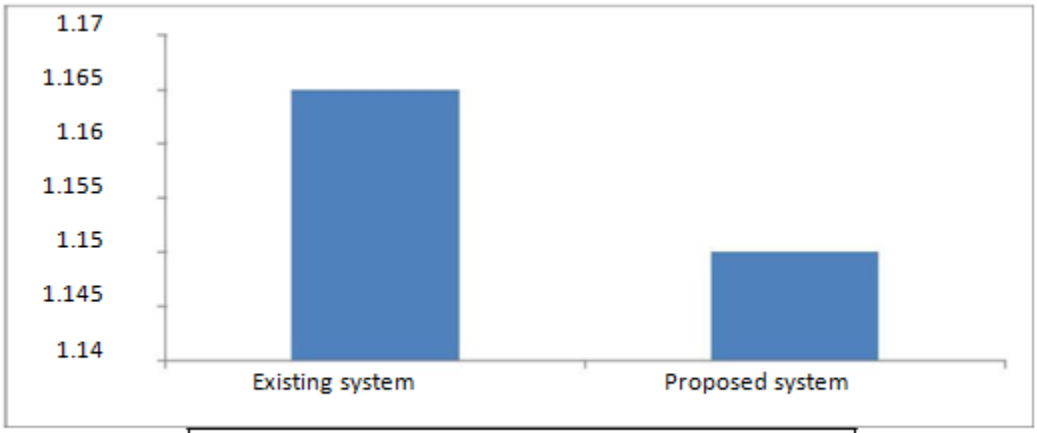

Fig:4.3 Comparison of Mass flow rate

From the above fig it is clearly noticed that the proposed system has less mass flow rate while comparing with the existing one. The mass flow rate is decreased by 12% from 1.165 to 1.15Kg/min.

ISSN 2348 – 8034
Impact Factor- 5.070

Comparison of power consumption:

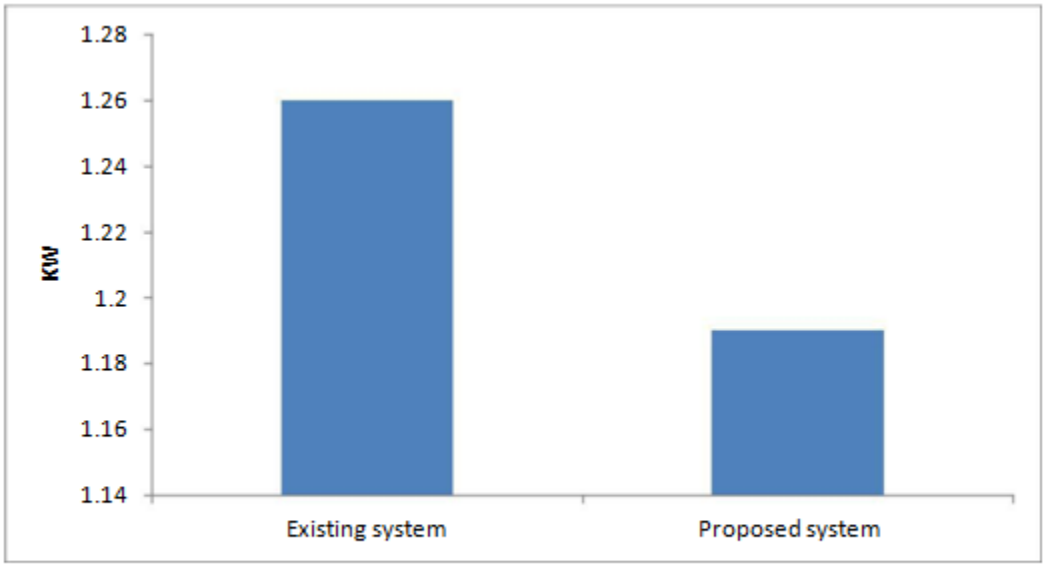

Fig:4.4 Comparison of Power consumption

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.

V. CONCLUSION

The performance of the refrigeration system is increased by introducing the twisted tapes into the condenser coil. High heat rejection through the condenser helped to increase the COP. These twisted tapes decrease the hydraulic diameter of the flow passage .This flow blockage increases the flow velocity and sometimes leads to secondary flow which further provides a better thermal contact between the surface and the fluid, finally results to a high heat transfer coefficient.

In the proposed system the cop is increased by 15.57%, Refrigerating Effect is increased by 10% , Power Consumption is diminished by 4.92% ,Work done by the compressor is diminished by 12% and Heat rejection is increased by 12.55%.

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