"Performance Analysis of VCR System Used In Household Refrigerator Using Twisted Condenser Tube"

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Abstract- *This paper presents an experimental investigation of heat transfer enhancement in an evaporative condenser, where the tubes are remodeled with rounded twisted tube types. In that project we use two types of condenser tube that are rounded one and another one is twisted tube. The heat transfer effect on both the tubes produces by using natural convection.Refrigerant R134a is used in the setup. The objective of this experiment is to enhance the heat transfer rate from condenser of simple VCRS Using twisted condenser tube. Also we are comparing the Actual/Theoretical Coefficient of Performance, Capacity and efficiency of V.C.R. system using rounded and twisted condenser tube. The result shows that the heat transfer coefficients of the twisted tubes are higher than that of the round one by 10%-15%.*

Keywords- Twisted condenser tube, Heat transfer enhancement, VCRS system.

I. INTRODUCTION

The enhanced heat transfer, which has been developed since 1960s as a new energy-save technique, can greatly improve the performance of heat exchanger including : (1) remodeling the heat exchanger's structure by the enhanced heat transfer element, (2) improving the fluid's physical property, (3) increasing the contact area by filling, and (4) surface disposal of heat transfer coil .

Majority of all heat exchanger applications in field of pharmaceutical industries, dairy, petrochemical, oil refining units power generation plants employ the use of conventional shell -tube type and plate type heat exchangers. It is estimated and observed that shell and tube technology is an economical, proven solution for a wide variety of heat transfer requirements. Several researchers conducted experiment and application of evaporative cooling system .However, the investigation of heat transfer enhancement in condenser by remodeling the tube type is rarely reported. When used in a refrigeration system, the shortcoming of twisted tube is the increase of the flow resistance of the refrigerant inside the tubes, and the flow resistance of air outside the tubes is also more than round tubes and elliptical tubes. The increase of resistance will increase the consumed power of compressor, fan.

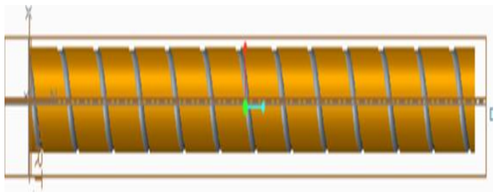

Fig. Twisted Tube

"Xiang-hue Tan et.al, stated that the heat transfer coefficient of the twisted tube heat exchanger is higher and the pressure drop is lower than the rod baffle heat exchanger. They also stated that analyze of the overall performance of the twisted tube shows that the twisted tube heat exchangers works more effectively at low tube side flow rate and high shell side flow rate. They stated that Even though enhanced tubes have higher heat transfer coefficient values, their h/Δp values are less than those of the plain tube due to their more pressure drops. From the above we can find that most of the researchers focused on the heat transfer and pressure drop performance of the twisted tube heat exchanger with traditional twisted tube is carried out for multi pass type of heat exchangers to obtain the better performance, the twisted tube heat exchanger and circular tube heat exchanger is experimentally studied in the present work and compared COP with each other. In present study, the twisted tube made of major and minor diameters of 10 mm and 4 mm respectively.shell- tube heat exchanger design. Hence, in present study the performance evaluation of the twisted tube.

II. PROBLEM DESCRIPTION

A condenser is a device that changes a vapor into a liquid state by cooling it into atmosphere. They can just as easily be called heat exchanger, because they extract the heat from a space, like a room, and send the heated air out into the atmosphere by natural convection. Condensers are one of the core pieces of equipment in air conditioning systems and refrigeration units and are made up of copper material generally. They are most recognizable by their tube and fin arrangement for better heat transfer rate on the back of refrigerators, inside a window air conditioning box, or as part of the exterior case in central air HVAC unit.

Copper tube is one of the components that is needed in Refrigeration system. The tube is used as path for the refrigerant to flow between system components and to contain it from escaping to the atmosphere. Sizing, installation layout and fittings should be done properly to ensure that the system runs efficiently. During installation, it is most importance that moisture, dirt and other contaminants are prevented from entering the system. These foreign particles will affect performance of the system and may even cause damage to some of the components.

When twisted tube used in refrigeration system, then it increase of the flow resistance of the refrigerant inside the tubes, and the flow resistance of air outside the tubes is also more than round tubes and elliptical tubes. The increase of resistance will increase the consumed power of compressor, fan.

The longitudinal vortex tube is replace by twisted tube for improves the velocity vector and temperature gradient, which in turn results in better heat transfer performance. The heat transfer coefficient of the twisted tube heat exchanger is higher and the pressure drop is lower than the rod baffle heat exchanger.

III. HEAT TRANSFER ENHANCEMAENT TECHNIQUES

- Heat transfer enhancement is the fastest growing areas of heat transfer technology.
- The technologies are classified into two ways such as active and passive techniques depending on how the heat transfer performance is improved.
- A twisted tube is a typical passive technique that uses a specific geometry to induce swirl on the flow inside the tube.
- Twisted tube technology provide more heat transfer coefficient possible in tubular heat exchanger.
- The tube ends are round to allow the conventional tube to tube sheet joints.
- Swirl flow in tube create turbulence to enhance heat transfer.
- By keeping the flow turbulent a high heat transfer performance can be achieve.

IV. EXPERIMENTAL SET-UP

The setup consist of hermitically sealed compressor, air cooled condenser, expansion device & coiled evaporator. The evaporator coil is immersed in a freezer fitted with electric heater. The heater coil is controlled by dimmer. Refrigerant R134a is used in the setup. The measuring instruments are provided to measure the temperature and pressure of refrigerant cycle, refrigerant flow, power supplied to compressor and heater load. The system works in a closed cyclic operation with the help of heat transfer media called 'refrigerant'. This refrigerant changes the phase whenduring passing through evaporator and condenser to exchange the heat. Refrigerant vapor is compressed by means of a compressor up to pressure at which temperature obtained at the end of compression will be more then atmosphere so that at this high temperature will reject heat to the atmosphere and will get condensed. The condensate is then allowed to pass through a capillary so that pressure and temperatures and lowered. Capillary device acts as a throttling unit. At low temperatureand pressure refrigerant supplied to evaporator where load is kept, it absorbs heat and refrigerant get converted into gaseous phase and it is again supplied to compressor and cycle is repeated. In that experiment we use two types of condenser tube such as rounded one and another one is twisted tube. Both are made by copper because copper tube provide high heat transfer rate. Both the tubes are placing parallel at the outlet of compressor and inlet of expansion valve. The walls are used for passing the separate flow through the condenser tube. Digital thermocouples are used for measuring the temperature at every point. Also pressure gauges are use for measuring the evaporative and condenser pressures. Rota meter is use for measuring the amount of heat supply in evaporator by heating coil.

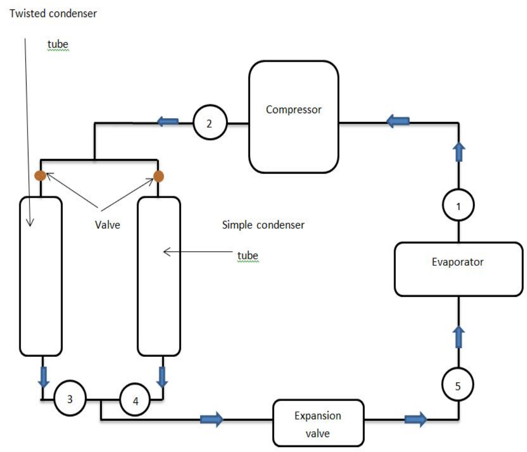

Fig. Line diagram of complete setup

OBSERVATION TABLE:-

Particular	Circular Tube	Twisted Tube
High Pressure/Condenser Pressure (Pc in bar)	9.97	9
Low Pressure/Evaporator Pressure (Pe in bar)	3.14	2
Refrigerant Inlet Temp to Evaporator in°C(Tei=T1)	5	3.4
Refrigerant Outlet Temp from Evaporator in °C (Teo=T2)	16	25
Refrigerant inlet Temp. from condenser in°C(Tci=T3)	48	38
Refrigerant outlet Temp. from Condenser in°C(Tco=T4)	33	33
Time for 10 Pulses of Compressor energy meter in sec (tc)	122	136
Refrigerant volumetric flow Rate (Vr) in LPH	3.5	4

V. CALCULATION

A) For Circular Tube:-

1. *Theoretical C.O.P*= $\frac{h_1 - h_4}{h_2 - h_1}$

Where,

h_1 = Enthalpy of gas at evaporator inlet

h_2= Enthalpy of gas at evaporator outlet

h_3= Enthalpy of gas at condenser inlet

h_4= Enthalpy of gas at condenser outlet

h_1, h_2, h_4 are enthalpies to be taken from P-h chart for refrigerant R134a

Theoretical C.O.P =$\frac{415-245}{438-415}$

Theoretical C.O.P = 7.39

2. *C.O.P (Act)*: = Refrigeration effect / Work done by compressor

. *C.O.P (Act)* =REact / Wact

Compressor Power(Wact) in kw =$\frac{Nc \ x \ 3600}{tc \ x \ EMC \ comp}$

Where,

Nc = 10 (no of blinking/pulses counted for energy meter of compressor)

tc = Time for 10 Pulses of energy meter in sec

Emc(Comp) = Energy Meter constant.=3200

Compressor Power (Wact) = $\frac{10 \times 3600}{122 \times 3200}$

Compressor Power (Wact) = 0.092 kw

Refrigerating Effect (Theoretical) = mr $\times$(h1 – h4)

Where ,

mr =Mass flow rate in Kg/min

Mr= (Vr$\times$ 1.66x10^{-5}) /Vs

Vr-Volumetric flow rate in LPH (1LPH=1.66x10-5 m3/min)

Vs- SpVol of refrigerant at inlet to compressor

Let, Vs = $\frac{1}{\rho}$ = $\frac{1}{15}$ = 0.066m^3 /kg

mr = $\frac{3.5 \times 1.66*10^{-5}}{0.066}$

mr = 8.80 $\times 10^{-4}$ kg/min

Now, RE = mr$\times$ ($h_1 - h_4$)

RE = 8.80 $\times 10^{-4}$ (414 – 245)

RE = 0.1406 kJ/min

Actual COP = $\frac{0.1496}{0.092}$

Actual COP = 1.62

B) For Twisted Tube:-

1. Theoretical C.O.P = $\frac{h_1 - h_4}{h_2 - h_1}$

Theoretical C.O.P = $\frac{417-240}{437-417}$

Theoretical C.O.P = 8.85

2. C.O.P (Act): = Refrigeration effect / Work done by compressor

C.O.P (Act) =REact / Wact

Compressor Power (Wact) in kw = $\frac{(Nc \ x \ 3600)}{(tc \ x \ EMC \ comp)}$

Where,

Compressor Power (Wact) = $\frac{10 \times 3600}{136 \times 3200}$

Compressor Power (Wact) = 0.0827 kw

Refrigerating Effect (Theoretical) = mr$\times$ (h1 – h4)

Where

mr =Mass flow rate in Kg/min

$$mr = \frac{Vr \times 1.66 \times 10^{-5}}{Vs}$$

Vr-Volumetric flow rate in LPH (1LPH=1.66x10^{-5} m3/min)
Vs- SpVol of refrigerant at inlet to compressor

Let, Vs = 1/ρ = 1/14 = 0.0714m^3/kg

$$mr = \frac{4 \times 1.66 \times 10^{-5}}{.0714}$$

mr = 9.29$\times 10^{-4}$ kg/min

Now, RE = mr$\times$($h_1 - h_4$)

RE = 9.29$\times 10^{-4} \times (417 - 240)$

RE = 0.164 kJ/min
Actual COP = 0.164/0.0827

Actual COP = 1.98

VI. CONCLUSION

In this paper, the enhanced heat transfer method by remodeling the heat transfer tube types in the Condenser is investigated. The experimental tests for simple circular condenser tube and with a traditional twisted tube to compare COP of the system. The conclusions are listed as follows:

(1) The heat transfer tube's configuration in an condenser plays important role on the heat transfer coefficient. The results show that the heat transfer coefficient 14.6%-28.9%, higher than that of the round tube.
(2) By using twisted tube the COP and efficiency of the system can be increase but one disadvantage is that remodeling of circular tube is quick expensive

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