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Fabrication and Analysis of Ellipse Shape Coil Evaporator Refrigeration System

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Abstract -- A refrigerator is the one of the most useful home appliance for daily need which will either cool maintain a body at a temperature below that of surrounding. Majority of refrigerators works on vapour compression refrigeration system. The system use full for use full for upper middle class and business purpose of fastest ice making vapor compression system and it will also use full for making ice bricks in very less time consists. in summer time this refrigeration system was very use full at the time of less power supply this system was very short time supply high rate of cooling. The major considerations of the refrigeration system is to increase the performance of the system by increasing supply of cooling with short period in commercial areas and cool storages cooling increasing evaporator increased by the changing the shape of the evaporator and by extended surfaces. By Changing system shape and size to increasing cooling effect increasing and also taking less space less time with more compactable with high performance comparing to the modern refrigeration systems. Fabrication of the ellipse shaped evaporator coil to increasing to release cooling effect and to delivers it to out and enhancing performance to compare this system with the existing evaporator in the vapor compression refrigeration system. In these experiment used by 195 Litres capacity of domestic refrigerator pervious performance is better than now in these performances and also in the coefficient of performance.

I. INTRODUCTION

In 1972, Du Pont, one of the leading chloro-fluoro carbon (CFC) manufacturers, discussed the effect of their products on the environment. Ray McCarthy summarized that fluorocarbons are intentionally or accidentally vented to the atmosphere which may be either accumulating in the atmosphere and/or returning to the land or sea in pure form or as decomposed products. Du pont, investigated the effect of these compounds due to its presence in the atmosphere on living beings, plants etc. As a result CFC manufacturers formed the fluorocarbon panel to investigate the environmental impact of the CFC's. Molina and Rowland inferred that CFC's could destroy the stratospheric ozone. The atmospheric research programmed confirmed that CFC's were likely to deplete stratospheric ozone as predicted by Rowland and Molina, at the rate of 3% per decade. It was concluded that CFC's should be phased out, but that this could occur over a long period to minimize the economic impact on the CFC users. In 1984, a remarkable and totally unpredicted phenomenon was discovered by the British Antarctic survey, called "ozone hole". In 1987, government negotiated in the Montreal Protocol, the first international treaty and subsequently in other international protocols to protect the global environment. This agreement originally mandated in reduction in CFC production and consumption, but, importantly allowed for future revision in light of new scientific evidence. After the Montreal Protocol, the atmospheric concentrations of the most important chlorofluorocarbons and related chlorinated hydrocarbons have either leveled off or decreased. Halon concentrations chlorinated hydrocarbons have either leveled off or decreased. Halon concentrations have continued to increased, as the halons presently stored in fire extinguisher are released, but their rate of increase has slowed down and their abundances are expected to decline by about 2020. Also, the concentration of the hydro-chloro-fluorocarbons (HCFCs) increased drastically at least partly due to the fact that usages of CFCs (e.g. used as solvents or refrigerating agents) were substituted with HCFCs. While there have been reports of attempts by individuals to circumvent the ban, e.g. by smuggling CFCs from undeveloped to develop nations, the overall level of compliance has been high.

II. DESIGN AND FABRICATION WALK IN COOLER

a) Specifications:

Materials	Application
Compressor	1/2 HP
Relay	for electrical connections
5/6' copper tube	for evaporator
Capillary tube	for expansion (12 feet)
Condenser Air-cooled	for condensing the liquid
Filter drier	Dehydrator
Thermostat	Automatic defrost control
¼ tubes	Joining the tubings (4 feet)
Oil	for lubrication
Brazing rod	for brazing the tubings
Lead	For soldering
Wooden planks	For making the outer cabine
Wires	For electrical connections insulating the wires

b) Tools Required:

- Soldering Iron
- Brazing Rod
- Tube Cutter
- Hammer
- Carpentry Tools
- Charging Line Gauge
- Vacuum Pump

c) Designing of Container and assembling parts:

The sheet of 6mm gauge wooden sheet was used for making of container for refrigeration system. The sheet of 4feet ×2 feet was made use of and the development calculations are evolved. Now as the sheet is not big enough to take the center of 120 cm, hence the point was taken outside the sheet. The point was marketed making use of a string and marker pin. The angle was 90^0c after wards the height of 135 cm was marked and the undesired portion of the sheet is cut off, in a rectangular are on both ends of the sheet and attached in the shape of L as show in fig. Thus, the sheet metal of required tapering dimensions be obtained which is then soldered from the sides to get the internal container. Marketed the box for placing the evaporator with dimension of 45x25x35 cm arranging with help on hack saw, hammer and pines attachments as shown in fig

Fig. 1: front view of ellipse shaped evaporator refrigerator

Fig. 2: back view of ellipse shaped evaporator refrigerator

The sheet of 8mm gauge wooden sheet was used for making of container for refrigeration system. The sheet of 4feet ×2 feet was made use of and the development calculations are evolved. Now as the sheet is not big enough to take the center of 120 cm, hence the point was taken outside the sheet. The point was marketed making use of a string and marker pin. The angle was 90^0c after wards the height of 135 cm was marked and the undesired portion of the sheet is cut off, in a rectangular are on both ends of the sheet and attached in the shape of L as show in fig3.1.

Thus, the sheet metal of required tapering dimensions is obtained which is then soldered from the sides to get the internal container.

d) Assembling process of double condensing cooling system:

Brazing Process it is process of joining metal pieces by means of hard solder. Brass is mainly the main constituent of this solder. The brazing solder used in modern practice is commercially known as smelter, which is mixture of Cu, Zn and Sn. The most important phenomenon in this that the pieces to be joined are heated instead of the tube. Winding of Cu Tubes Once the internal container is repaired, it is soldered at its ends. Now 5/6" copper tubes of length onefeet were wound around the outer surface of the sheet metal internal container, with equal spacing between them. These "Cu" tubes were positioned in their place firmly and rigidly with the help of soldering at place. Now these assembly functions as our Evaporator and these coils are called as Evaporator Coils. Both the ends of the Cu tubes Viz, the top and bottom of the internal container, where left free or unwound the upper portion of the tube was taken below along the external surface of the container and finally taken out of the bottom of the plastic bucket through a small boring. The other end of the coil was connected to the accumulator which is placed in between the bottoms of the bucket and the container. Ten this end was also taken out of the same boring and connected to the capillary tubes.

- Capillary Connection:

One end of the capillary was brazed inside the accumulator to prevent leakage. The total length used for the purpose was 12feet. Initially, some portion of the capillary was wound around the 5/16' tube coming out from the lop surface of the container. Then, this capillary is made in the form of a uniform coil and was suspended freely. This capillary tube acts as an expansion valve.

- Dehydrator:

The dehydrator or the filter drier is located in the fluid line at the outlet end of the condenser. Its purpose is to filter, trap minute particles of foreign materials and absorb any moisture which may be in the system. Fine mesh screens filter out foreign particles and the desiccant absorbs the moisture. The one used in these refrigerator desiccants is silica gel (silicon dioxide).

- Condenser Connections:

Now a small piece of copper tubes id again brazed to the free end of he filter drier, which is then connected to the condenser. The condenser used in this unit is of air cooled type. In this the tube is bent in the shape of U and placed in conjunction with the fins are responsible for holding the air in their gaps that extract heat from the hot refrigerant flowing in the tubes of the condenser.

The evaporator coils surrounding the internal container absorb the heat from the hot boy inside the container and this heat is taken by the refrigerant. This refrigerant which is ultimate passing through the condenser radiates heat to the atmosphere with help of the condenser fins.

In our unit the condenser is fixed to the rear side of the cabinet, facing the atmosphere air.

- Compressor Connection:

The 5/6' copper tube of the evaporator oil is connected to one end the compressor with the help of brazing. The outgoing end of the compressor is brazed to the condenser to complete the circuit.

The compressor used in this case is reciprocating type sealed unit. The horsepower of the compressor is 1/6 HP. Compressor is used to establish a pressure difference and thus cause the refrigerant to flow from one part of the system to the other. At the same time the compressor raises the refrigerants pressure above the condensing pint.

At the temperature of the room air, so it will condense. It is this difference in pressure between the high low sides forces liquid refrigerant through the capillary tube an into the evaporator.

- Thermostat:

This is a temperature controlled electrical switch located on the evaporator wall. It is fastened to the evaporator will with a clamp at the lower region of the internal container. When the sensing element mounted on the evaporator wall senses the temperature lower than the operating conditions then it sends the signal to the thermostat switch immediately breaks the circuit in the relay and thus gets Tripped Off. The thermostat switch is connected to the relay. The rely thermostat has the bimetal strips, which is responsible for the make and break of the circuit.

- Gas Charging:

When the whole of the connections has been made then gas is charged with the help of the charging cylinder and the value is closed. The whole is now checked for the leakage by applying soap solution to the joints formed by brazing. Now when no leakage was there then the gas was filled. The amount of gas by weight was 15 ibs. The gas used for this was refrigerant R134A.

III. PERFORMANCE EVALUATION

With the data collected in experiments, different performance parameters are calculated as follows

- Mass flow rate of air is calculated as
  $m_a = \rho AVC_d$
  Where ρ is the density of air
  A is the area of cross section from which air is blown out, m^2
  V is the velocity of air, m/s
  C_d is Coefficient of discharge
- Heating capacity (kW) is calculated as
  $Q_h = m_a \times C_p \times (T_{out} - T_{in})$
  Where m_a is the mass flow rate of air, kg/s
  C_p is the specific heat of air, kJ/kg K
  T_{out} is the outlet temperature of air, ^0C
  T_{in} is the inlet temperature of air, ^0C
- Cooling capacity (kW) is calculated as
  $Q_c = m_w \times C_p \times (T_{in} - T_{out})$
  Where m_w is the mass flow rate of water, kg/s
  C_p is the specific heat of water, kJ/kg K
  T_{out} is the outlet temperature of water, ^0C
  T_{in} is the inlet temperature of water, ^0C
- Heat rejected by condenser is calculated as
  $Q_{hc} = m_r x (h_1 - h_2)$
  Where m_r is the mass flow of refrigerant, kg/s
  h_1 is the enthalpy of the refrigerant at the condenser inlet kJ/kg
  h_2 is the enthalpy of the refrigerant at the condenser exit kJ/kg
- Heat absorbed by evaporator is calculated as
  $Q_{he} = m_r x (h_4 - h_3)$
  Where m_r is the mass flow of refrigerant, kg/s
  h_3 is the enthalpy of the refrigerant at the evaporator inlet kJ/kg
  h_4 is the enthalpy of the refrigerant at the evaporator exit kJ/kg

IV. RESULT AND ANALYSIS

At the given suction pressure 20 Psi

1) Compressor suction:
   Pressure P_1 =1.4bar
   Temperature T_1 =38.6°C
2) Compressor discharge:
   Pressure P_2 = 16.26bar
   Temperature T_2 =79°C
3) Condenser parameters:
   Pressure P_3 = 12.45bar
   Temperature T_3 =42°C
4) Evaporator parameters:
   Pressure P_4 = 1.45bar
   Temperature T_4 =-4°C

From P-H chart, we can find out the values of h_1, h_2, h_3, and h_4 in KJ/Kg

h_1 =432.16KJ/Kg
h_2 =468.38KJ/Kg
$h_3 = h_4$=272.21KJ/Kg

- Net Refrigeration Effect :
  Net refrigeration effect can be expressed as
  NRE = $h_l - h_4$ = 432.16-272.21 =159.95 kj/kg

  where
  NRE = Net Refrigeration Effect
  h_l = enthalpy of vapor leaving evaporator
  h_4 = enthalpy of vapor entering evaporator
  NRE = $h_l - h_4$ = 159.95 kj/kg

- Capacity:
  c = q NRE = 0.4*159.95=63.98

  where
  c = capacity
  q = refrigerant circulated 0.4kg/s

NRE = Net Refrigeration Effect (Btu/lb)

- Compression Horsepower:
  Compression horsepower can be expressed as
  P = W / 42.4
  where
  P = compression power (hp)
  W = compression work (Btu min)
  Alternatively
  P = c / (42.4 COP)
  where
  P = compression power (hp)
  c = capacity (Btu/min)
  COP = coefficient of performance

- Compression horsepower per Ton:
  p = 4.715 / COP
  where
  p = compressor horsepower per Ton (hp/Ton)
  COP = coefficient of performance

- COP - Coefficient of Performance:
  COP = NRE / h
  where
  COP = Coefficient of Performance
  NRE = Net Refrigeration Effect
  h = heat of compression
  COP = 159.95/36.22= 4.41

- Heat of Compression:
  $h = h_2 – h_1$ = 468.38-432.16=36.22kj/kg

  Where
  h = heat of compression
  h_2 = enthalpy of vapor leaving compressor
  h_1 = enthalpy of vapor entering compressor

- Mass flow rate:
  oneTR,Kg/min 'mr' =210/159.95 =1.3129Kg/min

- Compression Ratio:
  $CR = p_h / p_s$ = 16.26/1.4 = 11.61

  where
  CR = compression rate
  p_h = head pressure absolute (psia)
  p_s = suction pressure, absolute (psia)

Heat equivalent of work of compression per ton r =mr x (h_2-h_1)=47.55KJ/min
Heat to be rejected in the condenser $=h_2-h_3$=196.17KJ/Kg
Heat rejection per ton of refrigeration = (210/NRE)x(h_2-h_3) =261.488KJ/min

- Observations of praposed refrigerator:

At the given suction pressure 20 Psi

1) Compressor suction:
   Pressure P_1 =1.73bar
   Temperature T_1 =32°C
2) Compressor discharge:
   Pressure P_2 = 10.3bar
   Temperature T_2 =55°C
3) Condenser parameters:
   Pressure P_3 = 10.3bar
   Temperature T_3 = 33°C
4) Evaporator parameters:
   Pressure P_4 = 1.ba2r
   Temperature T_4 =-0.3°C

From P-H chart, we can find out the values of h_1, h_2, h_3, and h_4 in KJ/Kg

h_1 =400 KJ/Kg
h_2 =435 KJ/Kg
h_3 $=h_4$ =230KJ/Kg

- Calculating Performance Parameters:

1) Net Refrigeration Effect (NRE) $=h_1-h_4$ =400-230 =170KJ/Kg
2) Mass flow rate obtain, one TR,Kg/min 'mr' =210/NRE =1.316Kg/min
3) Work of compression $= h_2-h_1=$ 435-400= 35KJ/Kg
4) Heat equivalent of work of compression perTR= mr x (h_2-h_1)= 35KJ/min

a) Theoretical power of compression = 35/60 = 0.58KW
b) Co-efficient of performance (COP) = NRE/work of compression=170/35 = 4.85%
c) Heat to be rejected in the condenser= h_2-h_3=435-230 = 205 KJ/Kg
d) Heat rejection per ton of refrigeration (TR) =(210/NRE)x(h_2-h_3) =268.0692KJ/min

- Performance of a simple Compression Refrigeration Cycle:

The performance of vapor compression refrigeration cycle varies considerably with the ellipse shapes coil has greater effect. To illustrate these effects the calculated values at the different pressure existing and proposed systems have been plotted on the result analysis. The relationships between existing and proposed systems ratio of circular shaped coil and performance parameter have disused below.

From the total experiment average of circular shaped evaporator system C.O.P is increased up to 0.44% than the general domestic refrigeration system

By incorporating the circular shaped evaporator of the refrigeration system the C.O.P enhance of by 0.44%, as a result of 0.44% increase in refrigeration effect and 0.5% reduction in compressor work and same in heat absorption.

Further, system pressure is slightly increased, the circular shaped evaporator increases the C.O.P compared to existing evaporator, which is perhaps due to reduction in compressor work and increase in refrigeration effect.

According to this circular shaped evaporator of domestic refrigeration system performance is better compared with privies general domestic refrigeration system

V. CONCLUSION

In the present work, experiments are conducted for the circular shaped design evaporator of a vapor compression refrigeration system used for a domestic refrigerator of 195 liters capacity.

The data obtained from the fabricated experimental set-up is used to analyze the performance of ellipse shaped evaporator of a vapor compression refrigeration system with existing evaporator of vapor compression refrigeration system.

By increasing coefficient of performance of 0.4% to increasing working performance of refrigeration cycle and costumes less power per cycle and to decreasing maintenance cost comparing to the domestically refrigerator system to fast up the precaution of ice with less time.

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