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Design And Analysis Heat Recovery System Based On The Heat Pump Principle

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Abstract- Decreasing of power consumption and recovering waste heat which is lost to the ambient in the system. The heat recovery is done by using vapor compression refrigeration system. Increasing of coefficient of performance of the system. We use shell and tube condenser for effective result and refrigerant as R134a. Reducing the power consumption by the heater due to the heat recovery system . Design of the heat recovery system is done and it is analysed. We choose the refrigerant based on its properties. We choose condenser material and evaporator material based on the material properties. Compressor is selected based on the requirement that is of 6KW and the coefficient of performance gets improved. We use expansion device to reduce the pressure and we choose its length based on pressure reduction.

Index Terms- R134a, Coefficient of performance, Shell and tube Condenser, Evaporator, Compressor, Expansion

1. INTRODUCTION

The essential components of vapour compression refrigeration system are Evaporator, Condenser, Compressor and Expansion device. In this refrigeration system we extract heat from the low temperature and send it to high temperature it helps in the improving of the coefficient of performance of the system. We choose refrigerant as R134a based on the properties because it is so efficient and non-toxic in nature. We use shell and tube heat exchanger because of efficient working of the water cooled condenser. We choose water cooled condenser over air cooled condenser based on the requirement. For improving of coefficient of performance we have different option using of better heat exchanger, reducing of compressor work or improving the design of evaporator.

1.1.types of evaporators:-

1) Dry expansion type of evaporators
2) Flooded type of the evaporators

1.2.type of evaporator based on the construction :-

1) Bare Tube Evaporators
2) Plate Type of Evaporators
3) Finned Evaporators
4) shell and tube evaporator

2. LITERATURE SURVEY

- Petter Neska [1], Heat pump working fluid as co2 due to environmental concerns and energy consumption is reduced to 75%compared to electrical or gas fired system.
- J.Perko[2], Cost comparison of gas heating and heat pump and for gas heating it is high.
- [3], COP of air cooled refrigerator is 6.28 and the COP obtained for water cooled condenser is 9.5. Thus COP is increased by 51.27%.
- [4], For same heat extraction from hot refrigerant after compressor, tube length required for designed condenser is much smaller than air cooled and shell and tube heat exchanger. This reduce cost as well as weight of system, also COP of system is improved significantly
- [5], Water cooled condeser are more efficient than air cooled condenser
- [6], COP of the system is much higher than the COP of hot walled condenser. The Water cooled condenser gives an average COP of 3.55 compared to 2.20 of hot walled condenser.
- [7], In water-heating process, the water temperature in tank was guaranteed to be stable and temperature stratification was almost eliminated for variable-diameter coil design. Heat transfer coefficient of variable-diameter coil was 587.76 W/(m2 K), 19.06%higher than the constant-diameter coil. Moreover, compared to constant-diameter coil design, average COP was 3.97% higher
- [8], The investigations on the relative humidity influence showed that an increase of 6% of the

initial value leads to a maximum reduction of heat transfer is of 30 % and occurs at the highest dry bulb temperature.C.

3. NOTATION

T1 =Temperature before compressor

h1 =enthalpy before compressor

T2 =Temperature after compressor

h2 = enthalpy after compressor

M* =Mass flow rate

h3 =enthalpy after evaporator

h4 =enthalpy before condenser

Cp =Specific heat

Wc =work of compressor

Qc =heat rejected by the condenser

Qe =heat absorbed by the evaporator

3.1.condenser design

h0 = 0.725[kf^3þf^3ghfg/NDµ(T2-T1)]

Uw =(m*/þ)/((no of tubes/no of passes)*inside area)

Re= þvl/µ

Nu=hd/k

Pr=µCp/k

Nu=0.023Re^0.8Pr^0.4

$1/U_0$ =(1/h_0 *(At/ηAf+Ab))+(At/hiAi)+(At/hfAi)

Ae=Qc/U*Δt A0=Ae/(At/Ao)

l=Qc/U_0 ∏Dlmtd*no of tubes

hi=0.023(Re)^0.8(Pr)^0.4*K/D

3.2.formulas for design calculation :-

q= m cp(t1-t2) in W

h2= hg + cp (t2-t1)

S2= Sg + cp ln (t2/tg)

HRR= Qc/Qe =(1+1/COP)

Qe = m*(h1-h4)

COP=(Refrigeration effect/work input)

3.3.values obtained:-

Compressor work = 2.22206213 KW

Heater capacity = 21KW

Refrigeration capacity = 9.30KW =2.65tr

Refrigeration effect = 115 KJ/Kg

mass flow rate of refrigerant (m*) =0.083Kg/s

specific heat of water (Cp) =4.187 KJ/Kg K

3.4.condenser calculation.

outer diameter (do)= 0.0254 m

inner diameter(di)= 0.019 m

Lmtd= 10.9696299 º C

Qcondenser= 11.52650657 KW

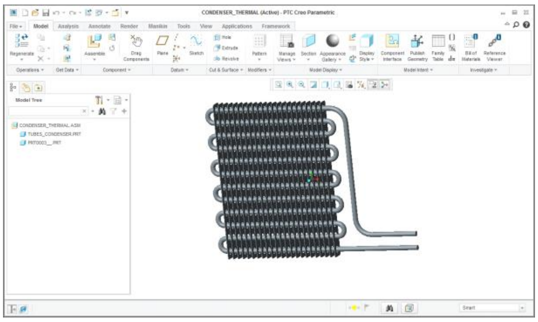
overall heat transfer coefficient (Uo)= 213.2 W/m^2K

extended surface area (Ae) =4.92842928 m^2

outside or bare tube surface area= (A0) 0.741 m^2

length of each tube =0.464 m

total length of the tube (l)= 18.583m



3.5. evaporator calculation

Outer diameter of the tubes, d_o = 31.0 mm

Inner diameter of the tubes, d_i = 25 mm

Nu =ho * do / k, ho = k * Nu / do 46.22

Evaporator Inlet Quality, x = 0.400

hi =343.09 KJ/Kg

Log Mean Temperature Difference (LMTD) = 18.7˚C

U= 104.59 W/m^2K

length of the pipe = 24.42 m

Length of the each pipe = 0.66m

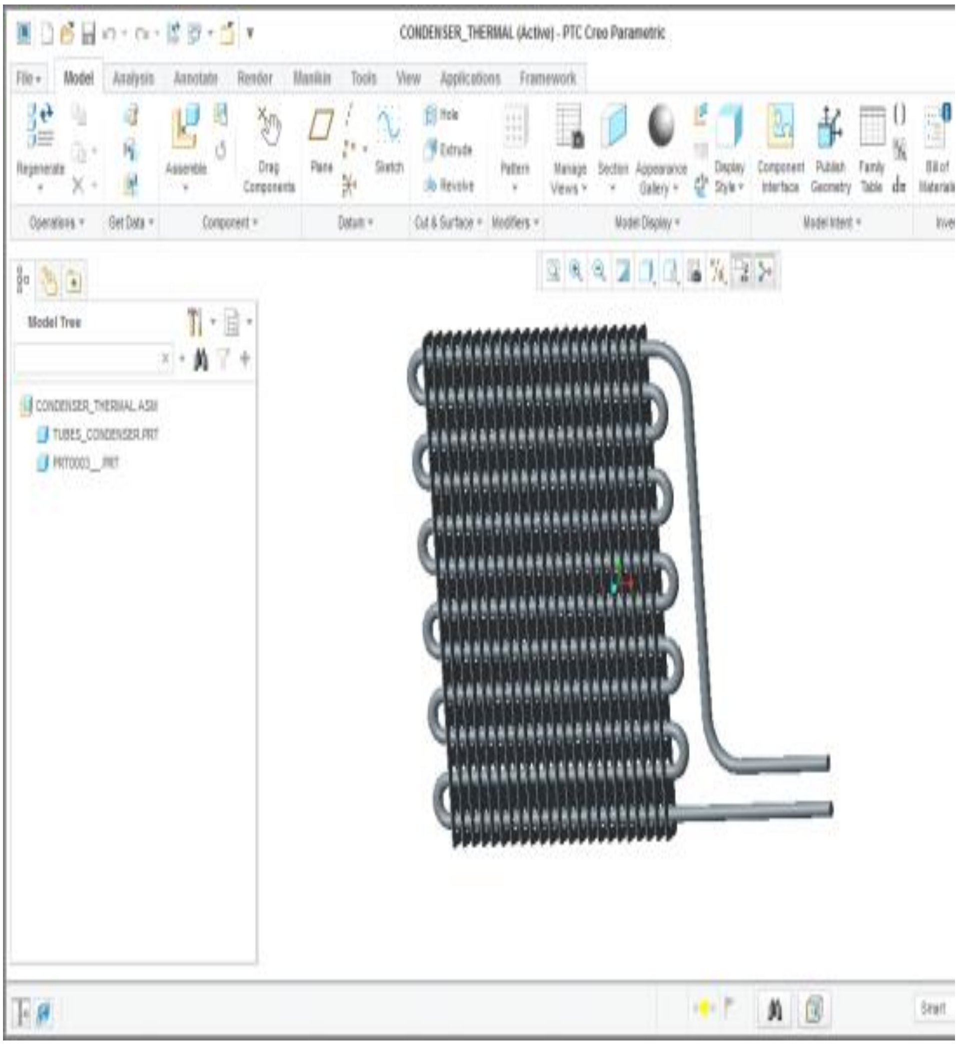


Fig. 1. condenser

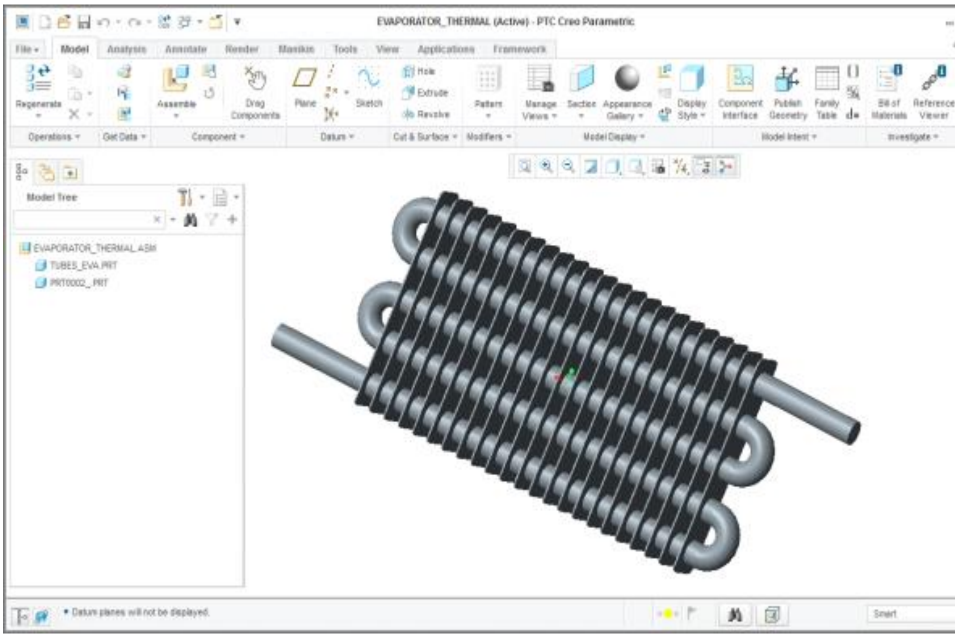
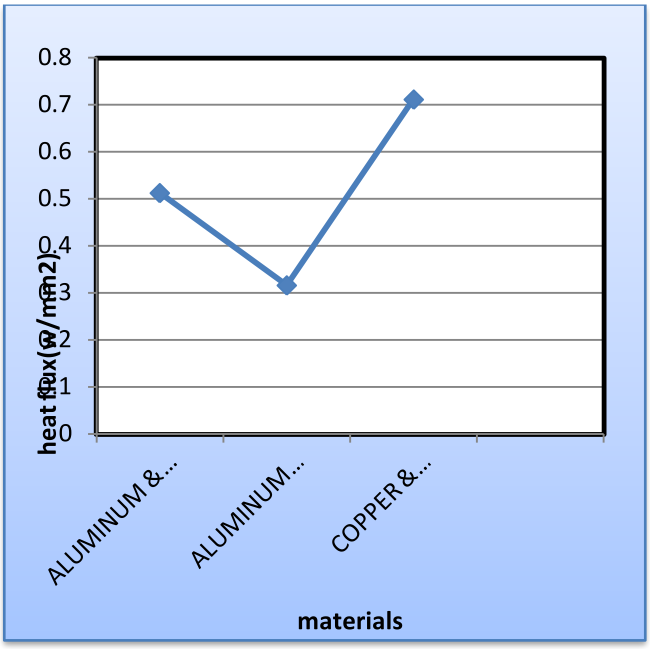


Fig. 2. evaporator

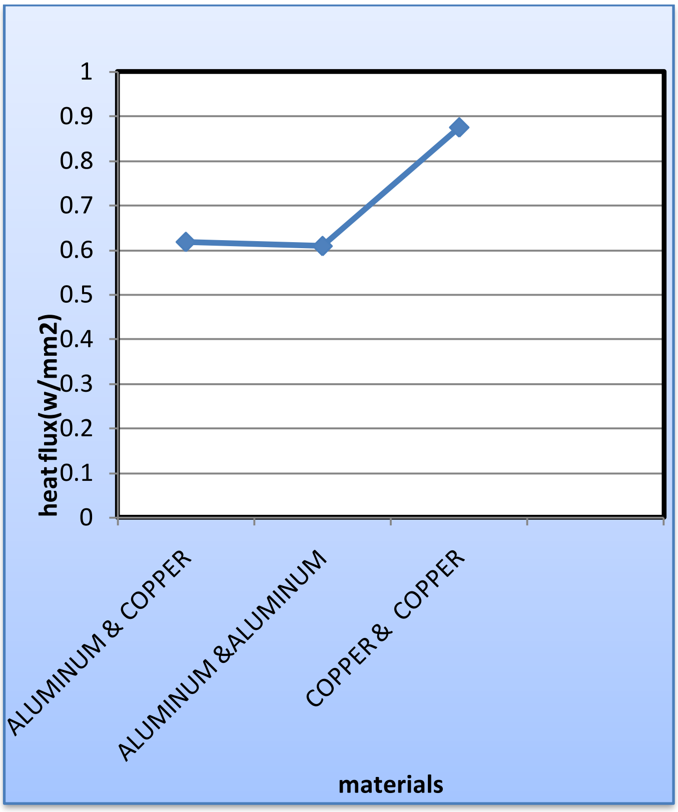
Materials	Results		Evaporator	Condenser
FIN MATERIAL ALUMINUM & TUBE MATERIAL COPPER	Temperature(^{0}C)	Max.	22.56	66.274
		Min.	14.904	31.66
	Heat flux(w/mm^2)		0.51302	0.6172
FIN MATERIAL ALUMINUM & TUBE MATERIAL ALUMINUM	Temperature(^{0}C)	Max.	22.419	65.187
		Min.	14.802	30835
	Heat flux(w/mm^2)		0.3162	0.60795
FIN MATERIAL COPPER & TUBE MATERIAL COP	Temperature(^{0}C)	Max.	22.28	65.167
		Min.	14.89	43.71
	Heat flux(w/mm^2)		0.71244	0.87402

Graphs

Heat flux plot of evaporator



Heat flux plot of condenser



It is the comparison of the heat flux between condenser and evaporator by using the different materials. Based on the fin material and the tube material heat flux distribution is compared. The distribution in the copper will be higher due to the higher thermal conductivity. When cost is concern the aluminum is efficient**.**

SCFD ANALYSIS RESULTS TABLE

Results	Evaporator	Condenser
Pressure (Pa)	**5.43e+04**	**1.16e+05**
Velocity(m/s)	**6.51e+00**	**5.59e+00**
Temperature(K)	**3.43e+00**	**2.88e+00**
Heat transfer coefficient (w/m2-k)	**3.85e+04**	**8.85e+02**
Mass flow rate(kg/s)	**0.012698174**	**0.017299771**
Heat transfer rate (W)	**9659.9219**	**1926.1855**

4. RESULT

1) By the above calculation the coefficient of performance is 3.5.

2) By the above comparison we can choose best material for condenser based on the cost concern and properties.

3) By the above comparison we can choose effective material for the evaporator based on the property and cost concern.

4) By the using above vapour compression refrigeration system we reduce power consumption

5. CONCLUSION

By the above analysis we can choose perfect material for both condenser and evaporator. We can reduce power consumption in the system and power conservation is done

REFERENCES

[1] CO2 heat pump water heater characteristics , system design and experiment results[PETTERNEKSA][FEB1998,PΠ:S0140-7007(98)00017-6]

[2] Calculation and design of the heat pumps[J.PERKO] [JULY2011].

[3] Performance Assessment of Water Cooled Condenser on Refrigeration System[MAY 2002]

[4] Design and Development of Water Cooled Condenser for Domestic Refrigerator (may 2016, ISSN 2277-7261)

[5] Comparative study of air cooled and water cooled condenser of a cold storage (may 2016, ISSN 2320-8163)

[6] Design and Analysis of Water Cooled Condenser (june2017, ISSN 2348-8360)

[7] Simulation and performance analysis on condenser coil in household heatpump water heater(Sustainable Cities and Society 36 (2018) 176–184)

[8] Experimental Investigations on Evaporative Condensers Performance (Energy Procedia 140 (2017) 458–466)