Enhancing Heat Transfer Rate by Optimization of Commercial Refrigeration Condenser and its Design Metrics

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Abstract

Optimization of Heat transfer rate & size of Heat money changer (condenser) by2significanttestsmetby Refrigeration structureproposals.The Heat transfer rate problem is concerned with the determination total heat transfer rate, and the sizing issueIs worried for those determination of the aggregate high temperature exchange surface range. The key element helping for higher heat exchange rate & base high temperature exchange zone may be those refrigerant streams out in the condenser coil, likewise those framework lies over indoor of a bureau. The objective of the available task is will streamline those outlinedof a commercial refrigeration condenser to enhancement the heat transfer rate. CFD (Computational Fluid Dynamics) and Condenser software will be used to optimize the design of thecomponents. Structural dissection about parts will be also will be performed with dissect the deformations & anxieties happening because of weights & temperatures of the stream. The necessary modifications are made to improve the heat transfer rate & reduce size of condenser that enhances the overall heat transferrate.

Keywords: Condenser design, Refrigeration, condenser circuit, CAD & Analysis.

1. Introduction

The main objective of this Project is to reduce size of the condenser and enhance the heat transfer rate. The Condenser is a device which used to exchange the heat absorbed to ambient. It rejects heat to external cooling medium (air or water). May be those procedure of evacuating high temperature from an encased space, or from An substance, Furthermore moving it will a spot the place it camwood a chance to be excluded in high face area, low FPI & optimum refrigerant flow through condenser coil and air flow over the condenser coil are the key for effective condenser performance.

In the present study, the condenser coil circuit is optimized so that the refrigerant flow through the condenser flows via two tubes parallels and the heat exchange between the refrigerant and the external surface occurs very quickly.

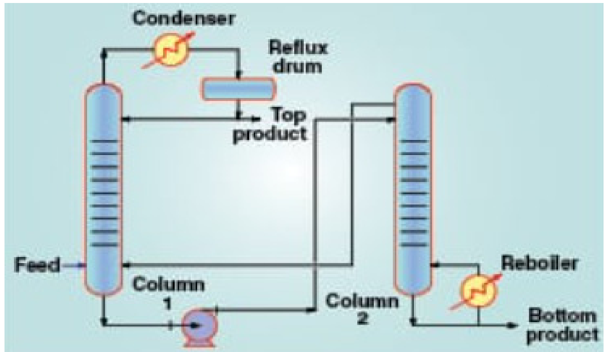

Fig.1 Detail explanation of Condenser with phase change.

2. Experimental Setup ofCondenser Optimization

The issues that mainlyeffect the heat transfer rate in a required convection type condenser

2.1 Air Cooled Condenser Selection

Air cooled condenser might be common convection sort alternately constrained convection sort. On practically as a relatable point we utilize air cooled condenser. In front of measuring a condenser, cautious assessment of the necessities for a particular establishment will be fundamental. The assessment ought to include, attention from claiming starting cost, operating cost, administration an aggregation Furthermore kind about load. A condenser that is excessively little camwood make unreasonable What's more make operating issues in easier encompassing states a under-size condenser camwood make working issues in higher encompassing states. It is, therefore, paramount with think about those taking after factors in front of measuring a condenser:

1. Terrible heat dismissal.
2. Encompassing temperature.
3. Consolidating temperature.
4. Temperature distinction (TD).
5. Wind stream.

Condenser ability is a capacity of the essential high temperature exchange equation.

$$Qc = U\,x\,A\,x\,LMTD$$

here

$$Qc = Condenser\ capacity\ in\ Cal/hr\ (Ref.effect + Heat\ of\ Comp + Motor\ winding\ heat)$$

$$U = Overall\ heat\ transfer\ coefficient\ K.Cal/m2Hr.°C\ A$$
$$= Effective\ surface\ area\ in\ m2$$

LMTD = Log mean temperature difference between the condensing refrigerant and the condensing medium in °C

Facearea = Air quantity / Airvelocity

The greatest speed happens between those tubes since the tubes blockan and only those streams acceptably. If B is those dividing among tubes in the face and cmay be the tube dividing among rows, also d may be those tube breadths. The Reynolds and Nusselt number are defined as follows for this case:

Re = (ρ x do x U∞) / μ

The Grimson's correlation is as follows

Where the constants *C* and *n* are dependent upon Reynolds number.

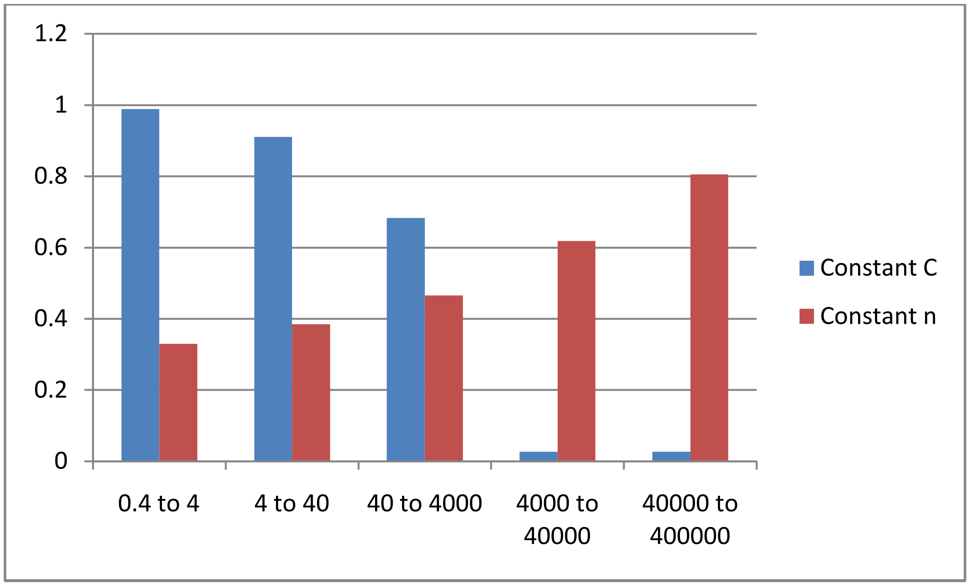

Figure.2. Constant for Grimson's Equation

Design ofCondenser

Design Considerations

Tube Size		3/8th
Outside diameter of thecondensertube	:	0.0079
Inside diameter of thecondenser tube	:	0.0068
Refrigerantused	:	R404A
EvaporatorTemperature(°C)	:	7.2
CondenserTemperature(°C)	:	54
Sub coolingTemperature(°C)	:	10
Super heatingTemperature(°C)	:	10.8
CompressorPower(W)	:	678
CoolingCapacity(Btu/hr)	:	5460
AmbientTemperature(°C)	:	43

Enthalpy values taken from P-h chart

H_1=400KJ / Kg H_4=270KJ / Kg H_2 =430 KJ / Kg H_5=245 KJ / Kg H_3 =420 KJ / Kg H_6=245 KJ / Kg

Refrigerant Effect = $H_1 - H_6$

= 155 KJ / Kg

HeatRejectionCapacity (HRC) = (**Refrigeration capacity * power of compressor) *FOS**

= ((1.6) + (678/1000)) x 1.05 = 2.392 KW

Overall heat transfer coefficient

$1/U_O = (A_t / A_i) \times (1/h_{i\ condensation}) + 1/h_O$ $U_o = 47.46\ W/m^2\ K$

LMTD $_{condensation}$ = 7.61 °C

2.2 CADModeling

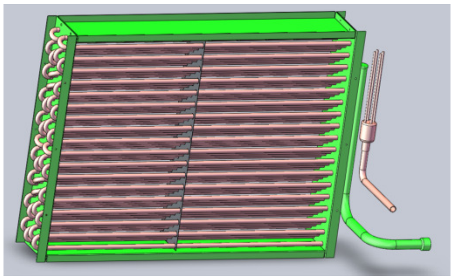

Figure.3. Existing design with 12 tube single circuit

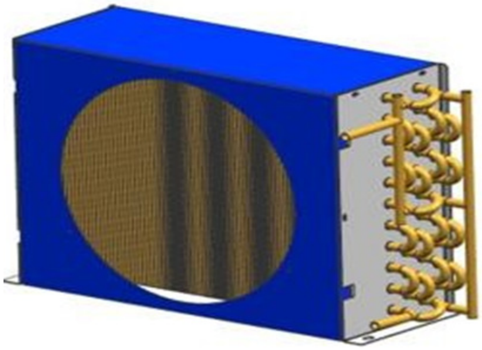

Figure.4. New design with 11 tube

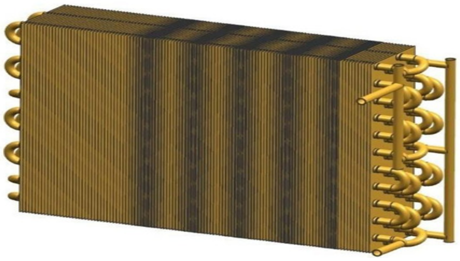

Fig. 5, Condenser coil with fins

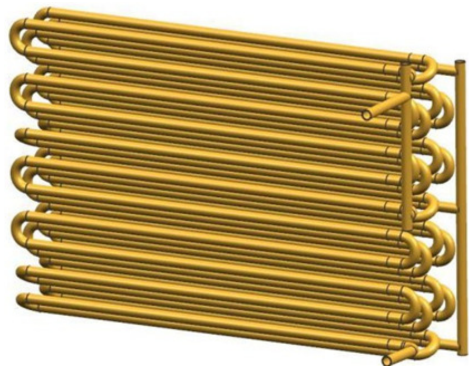

Fig. 6. Condenser coil without fins

Figure.7. Physical model of the design

2.3 ANALYSIS Structuralanalysis

Boundary Conditions:

Inlet: Temperature: 85 [C°]

Outlet: Mass flow rate = 0.0137(kg/s) Ref. Pressure: 14.7[PSI] Assumptions: Steady state single phaseanalysis.

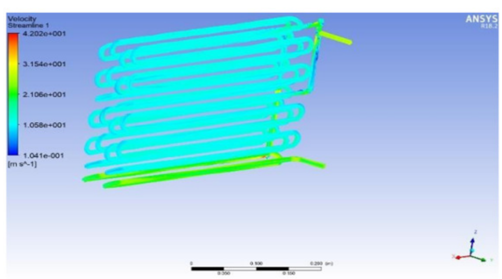

Fig. 8. 11*4 Row Condenser VelocityStreamlines

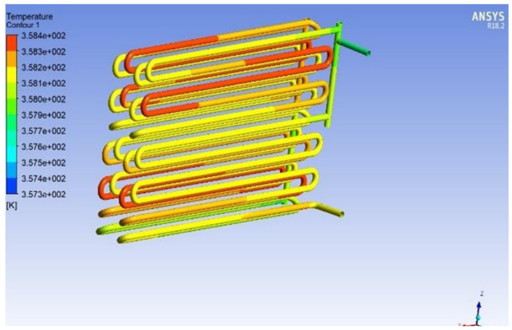

Fig.9. Temperaturecontour

	inlet	outlet
MFR	1.370e-02 [kg s^-1	-1.370e-02 [kg s^-1]
Velocity	2.751e+01 [m s^-1]	2.327e+01 [m s^-1]
Temp	3.581e+02 [k] (84.95 Deg.c)	3.177e+02 (44.55 Deg.c)

Table.2. Velocity and Temperature

Results and Discussion

By comparing the two models the outlet temperature of the new design is better.

By optimizing the circuit design from one circuit to two circuit the Heat transfer rate of the condenser is improved by 6% though the height of the condenser is decreased by 9 % by reducing one row of tube. The Capacity increased from3.17 KW to 3.37 KW. With this achievement the higher capacity of compressor can be used for the same refrigeration system and can be used in the very compact sized refrigeration units. The above data is calculated from the LUVATA Thest Condenser design Software and the images of the same are shown below

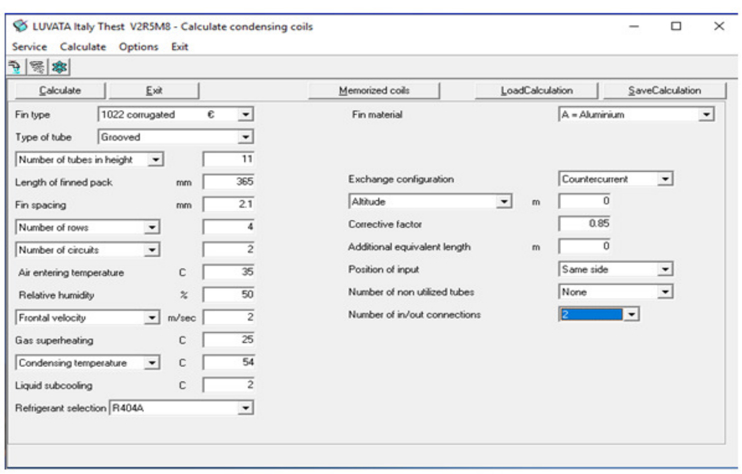

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Fig.10. Input for 11 Tubes Condenser

Ouput Video

ECO code	**1022A1104036521CXX(1+1)**			
Fin type	25 X 21.65 Staggered	1022 corrugated	1022c	(STD)
Type of tube	9.21 Grooved C			
Fluid	R404A			

Utilized tubes	44	HxLxP [mm]	275 x 365 x 87
Non utilized tubes	0	Outer area [m2]	7.53
Inner volume [l]	1.18	Frontal area [m2]	0.1
Headers		Inner area [m2]	0.465
Tubes per circuit	22		

AIR SIDE		SIDE -R404A	
Entering temp. [°C]	35	Delta superheating [°C]	25
U.R. entering [%]	50	T. condensing gas [°C]	54
Outlet temp. [°C]	49.5	T. condensing liq. [°C]	53.9
U.R. outlet [%]	23.4	Delta subcooling [°C]	2
Flow [m3/h]	722.7		
Flow [kg/s]	0.224		
Frontal velocity [m/s]	2	Total flow [kg/h]	81.8
Pressure drop [Pa]	38.1		
		Coil pressure drop [kPa]	6.53
Barometric pres. [kPa]	101.325	Pressure sat [bar]	24.9
Altitude [m]	0		

Type of calculation	Countercurrent	Total capacity [kW]	**3.37**
Corrective factor	0.85		
Additional equivalent lenght	0		

Fig.11. Output for 11 Tubes Condenser

Conclusion

By optimizing the circuit designs from one circuit to two circuits the Heat transfer rate of the condenser is improved by 6% though the size of the condenser is decreased by 9 % by reducing one row of tube. The Capacity increased from3.17 KW to 3.37 KW. With this achievement the higher capacity of compressor can be used for the same refrigeration system and can be used in the very compact sized refrigeration units. With this new design the cost of the unit can be reduced by about 5 to 6%. In conclusion, by optimizing the circuit design the performance of the condenser can be improved

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