Thermal Analysis of Refrigerator Evaporator Coils with Refrigerant Blends

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Abstract: The cold storages and refrigerators are typically found in most of the countries and that they are one amongst the foremost energy exigent appliances due to their continuous operation. In this paper, the thermal characteristics are analyzed by mixing R12 mixing with R134A, Ethylene glycol and propylene glycol with 0.03% volume fraction when used in a refrigerator. Theoretical calculations are done to calculate properties of the mixture of refrigerants. CFD analysis isdone on the evaporator coils to determine the heat transfer coefficients with and without mixed refrigerants. 3D modelling is done in Creo2.0 and analysis is done in Ansys14.5.
Keywords: Ansys14.5, CFD analysis, Creo2.0,Refrigerator, Evaporator Coils.

I. Introduction

The increase in Earth's atmosphere and ocean temperature referred to Global Warming problems are directly or indirectly blamed by the Refrigeration systems. Throughout early 1990, the second energy consuming appliance and most expensive is frost freezer after water heater. Absolutely it was mandatory for appliance manufacturers to incorporate labels that list estimation of the annual price of running the appliance, therefore customers may compare energy usage and prices.

II. Conventional Vapour Compression Refrigeration Cycle

A circulating liquid refrigerant is utilized as the medium for the vapour-compression since the medium absorbs and removes heat from the area to be cooled and after rejects that heat elsewhere. Between environment and evaporator coil via convection the main transfer of heat is done. Figure below shows a typical, single stage vapour- compression system. There are four components in such systems: condenser, compressor, evaporator and thermal Expansion valve. Circulating refrigerant enters the compressor in the thermodynamic state referred to as a saturated vapour and is compressed to a higher temperature.

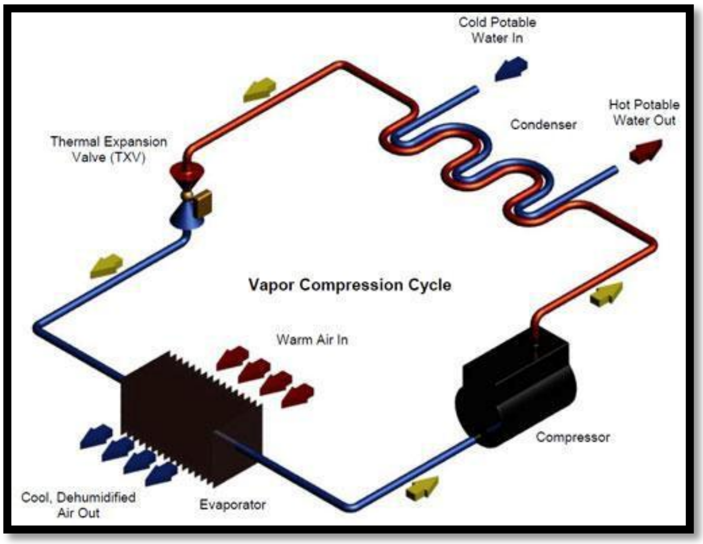


Fig – Single stage vapour- compression system

III. Literature Review

RezaurRahman et al. [1] rising performance of domestic refrigerator with PCM application with the evaporator are investigated. The investigator analyzed that usage of PCM will increments the rate of heat transfer and so improve the COP of refrigeration.

Md Imran Hossen Khan etal. [2] Experiments were done to research performance improvement of a house hold refrigerator with three completely different PCM's with different quantities at different thermal loads. 20% to 27% COP improvement is achieved with the use of PCM as compared with that of without PCM.

MD. MansoorAhamed et al. [3] improvement within the performance of a cold storage without and with PCM panels (Ethylene Glycol) is investigated.

Azzouz, K et al. [4] to research a household refrigerator performance using a PCM experiments were conducted. The PCM is found on the backside of the evaporator therefore on efficiency boost and to provide to provide to produce} a storage capability allowing several hours of refrigeration while not power supply.

J.F. Silvain et al. (1993) [5] studied the elastic moduli, thermal expansion and microstructure of copper matrix composite reinforced by continuous carbon fibers. Copper matrix composites bolstered by continuous carbon fibers (Cg) were processed by hot-pressing layers of antimonial pre-pregs, every fiber inside the yarns having antecedently been coated with copper by electroplating. Composites processed in step with this procedure were evaluated by tensile testing and by determination of thermal expansion coefficients and chemical and structural characterizations of the graphite/copper interface. An electroplate coating followed by diffusion bonding was found to be a made and original way to manufacture absolutely dense Cg/Cu laminated composites. Chromium is other to enhance the chemical bonding.

Wenlin MA and Jinjun Lu et al. [6] studied the impact of surface texture on transfer layer formation and tribologicalbehavior of copper–graphite composite. Metal matrix composites (MMC) containing carbon particulates typically have reduced friction below dry slippery, which is closely obsessed with the formation of continuous transfer layer on the slippery surface of counterpart. Friction and wear tests were conducted below low and high load conditions and varied slippery distances to gauge the validity of the textures and their impact on the formation of the transfer layer of Cu/Gr composite.

Haijun Zhao et al. [7] investigated the wear and corrosion behaviour of Cu–graphite composites ready by electroforming. Cu–graphite composites were ready by electroforming technique in associate acidic sulphate bathtub with carbon particles in suspension. The surface bonding between metal matrix and particles is way reinforced and body is eliminated within the composites just in case of electroforming. Corrosion takes place at grain boundaries instead of the interface between carbon particles and Copper matrix. Wear resistance is improved when the incorporation of carbon particles into copper matrix.

Simon Dorfman& David Fuksb et al. [8] studied the steadiness of copper segregations on Copper/Carbon Metal matrix Composite interfaces below alloying. Stability of interfaces in MMCs is joined to the conditions of the formation of segregations of the metal alloy at the metal/fiber interface. It's shown that alloying of the matrix, subbing copper within the opening metal-metalloid primary solid solution, changes the value of the blending energy and influences the quantity fraction of 2 dimensional segregations of copper. We have a tendency to expect that the wettability of carbon fibers by the pure copper matrix is also improved by the addition of tiny amounts of metal or iron to the matrix.

Dash, K., Ray, B.C. and Chaira, D. et al. [9] synthesized copper–alumina metal matrix composite by typical and spark plasma sintering so performed characterization. The composites manufactured by SPS route don't show any peak of Cuprous oxide as sintering was carried out in vacuum atmosphere. Presence of Cuprous oxides was determined within the Cu/Al_2O_3 interface within the EDS of the sample fancied by typical sintering in Hydrogen, Nitrogen and argon atmosphere. The density of composites form by spark plasma sintering technique is type of high as compared to the opposite techniques.

IV. Tables & Calculations

Properties of fluids				
	R-12	**R-134A**	**Ethylene Glycol**	**Propylene Glycol**
μw = Viscosity Kg/ms	0.0003462	0.0003949	0.0161	0.42
ρw = density Kg/m^3	1487.7	1382.4	1100	1036
C_W= specific heat KJ/Kg K	0.886	1.277	2430	2512.07
k_W=Thermal conductivity W/m.K	0.0869	0.1048	0.2577	0.34

Properties of mixed fluids			
	R-12 + R-134A	**R-12 + Ethylene Glycol**	**R-12 + Propylene Glycol**
μw = Viscosity Kg/ms	0.0003721	0.0003816	0.0003715
ρw = density Kg/m^3	1484.541	1476.069	1474.149
C_W= specific heat KJ/KgK	897.73	932.32	934.7821
k_W=Thermal conductivity W/m.K	0.08757	0.09032	0.09117

V. CFD Analysis of Evaporator Coils

Save Creo Model as .iges format.
→→Ansys → Workbench→ Select analysis system → Fluid Flow (Fluent) → double click
→→Select geometry → right click → import geometry → select browse →open part → ok

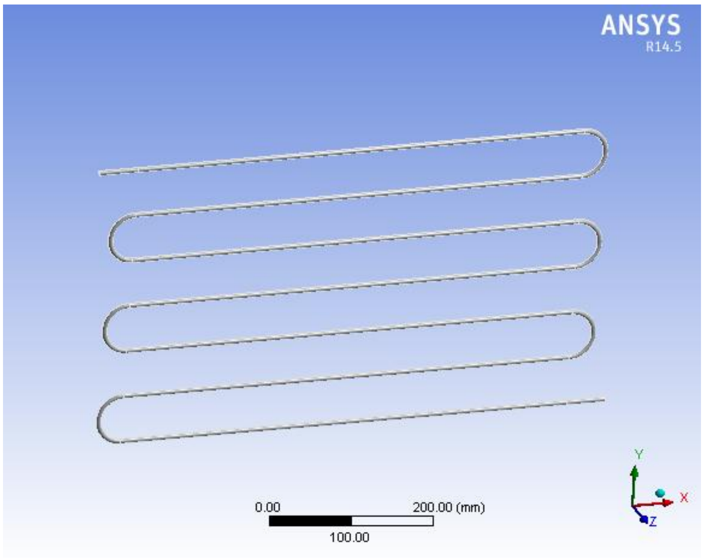


Fig: - Imported model

Select mesh on left side part tree → right click → generate mesh →

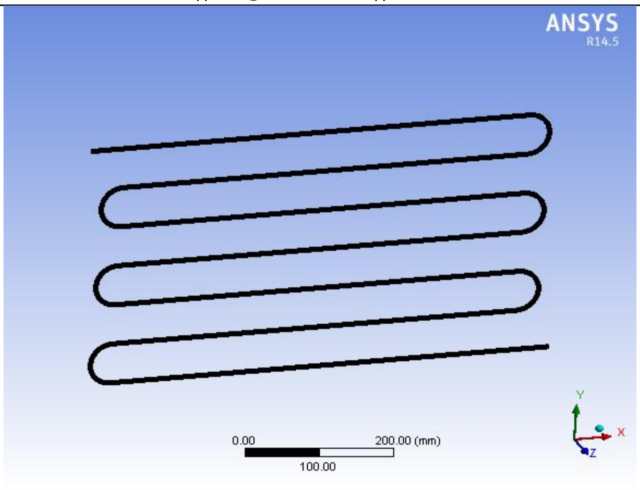


Fig: - Meshed model

Specifying boundaries for inlet and outlet

Select edge → right click → create named section → enter name → inlet

Select edge → right click → create named section → enter name → outlet

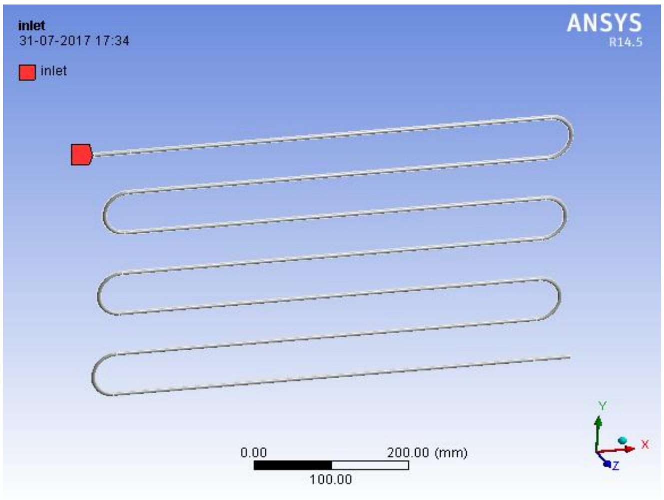


Fig: - Inlet

Select graphics and animations → select contours → select required result → display

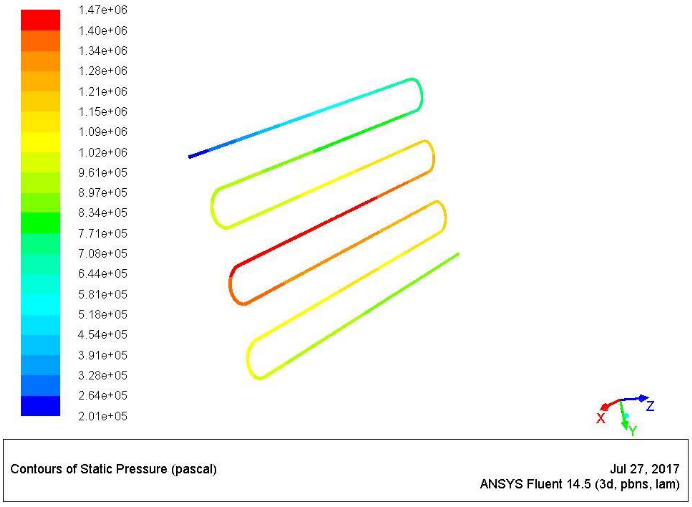


Fig: - Contours of Static Pressure

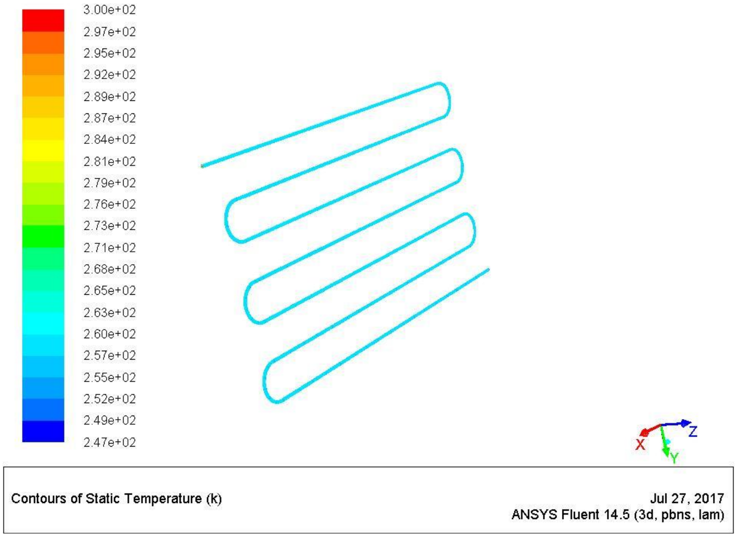


Fig: - Contours of Static Temperature

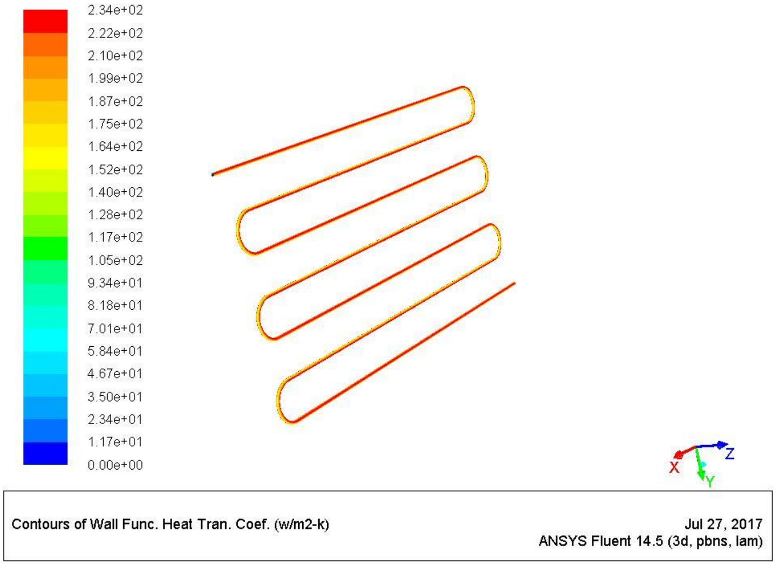
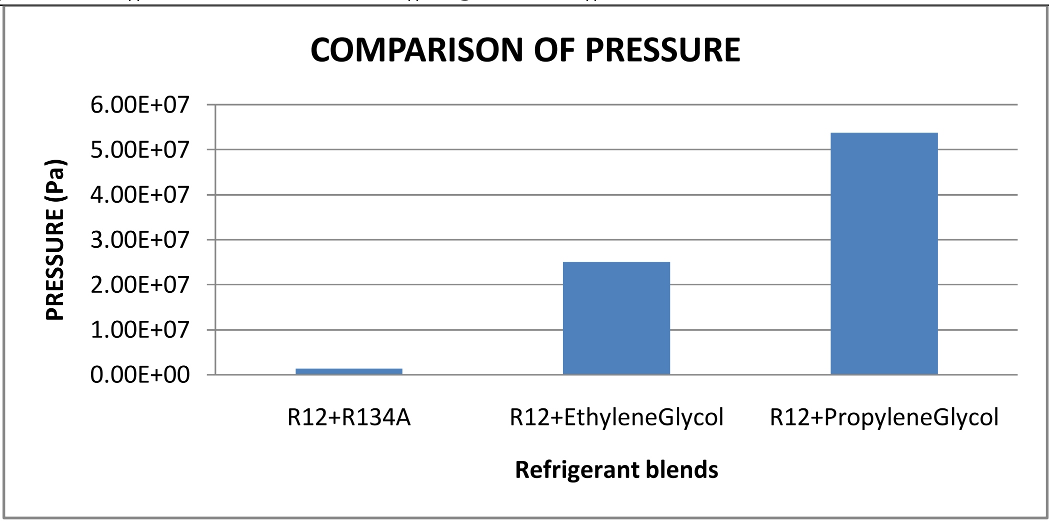


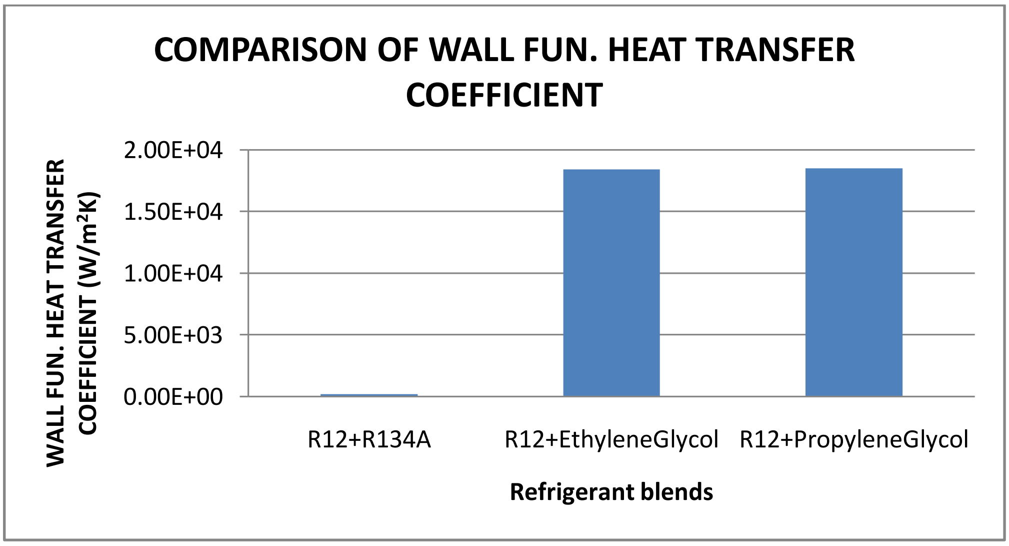
Fig: - Contours of Wall function heat transfer coefficient

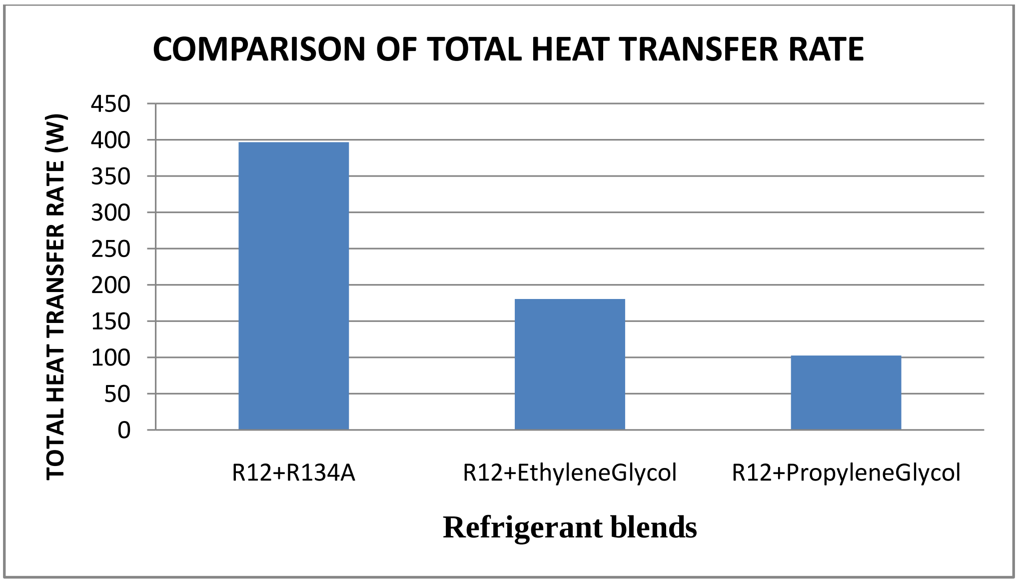
Select reports →fluxes→ select Total Heat Transfer Rate →select all domains →compute→ write →save location → mention name of file

VI. Result & Graphs

VII. Type of fluid	R-12 + R-134A	R-12 + Ethylene Glycol	R-12 + Propylene Glycol
Pressure (Pa)	1.47E+06	2.51e+07	5.38e+7
Temperature (K)	300	269	268
Wall fun. Heat trans. Coeff (W/m^2K)	234	184	185
Total heat transfer (W)	396.8962	181.2	103.292


COMPARISON OF PRESSURE
PRESSURE (Pa)
6.00E+07
5.00E+07
4.00E+07
3.00E+07
2.00E+07
1.00E+07
0.00E+00
R12+R134A
R12+EthyleneGlycol
R12+PropyleneGlycol
Refrigerant blends


COMPARISON OF WALL FUN. HEAT TRANSFER COEFFICIENT
WALL FUN. HEAT TRANSFER COEFFICIENT (W/m2K)
2.00E+04
1.50E+04
1.00E+04
5.00E+03
0.00E+00
R12+R134A
R12+EthyleneGlycol
R12+PropyleneGlycol
Refrigerant blends


COMPARISON OF TOTAL HEAT TRANSFER RATE
TOTAL HEAT TRANSFER RATE (W)
450
400
350
300
250
200
150
100
50
0
R12+R134A
R12+EthyleneGlycol
R12+PropyleneGlycol
Refrigerant blends

VIII. Conclusion

The thermal characteristics are analyzed by mixing R12 mixing with R134A, Ethylene glycol and propylene glycol with 0.03% volume fraction when used in a refrigerator. CFD analysis is done on the evaporator chamber to determine the heat transfer coefficients with refrigerant blends. From the CFD analysis, comparing the results between refrigerants blend, the heat transfer rate is more with R134A blend and heat transfer coefficient is more with Ethylene Glycol.

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