Research Article

Thermal Analysis on Evaporator Tube of 1.5 Ton Air Conditioning using AL99 (1100) Material

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Abstract

Air Conditioner (often referred to as AC) is a home appliance, system, or mechanism designed to dehumidify and extract heat from an area. In construction, a complete system of heating, ventilation and air conditioning is referred to as HVAC. Air conditioning evaporator works by absorb heat from the area that need to be cooled. It does that by maintaining the evaporator coil at low temperature and pressure than the surrounding air. Since, the AC evaporator coil contains refrigerant that absorbs heat from the surrounding air, the refrigerant temperature must be lower than the air. The main aim of present work is to do thermal analysis on evaporator with selected fin material and refrigerant. Presently the material used for coils is copper and the material used for fins is copper or aluminium G Al Cu 4IMG 204 whose thermal conductivity is 110-150W/m k. For present work the copper plate, Al99 (1100) and Al 204 plate material is used for fin. To validate the temperatures and other thermal quantities like flux and gradient, thermal analysis is done on the evaporator coil by applying properties copper and present fin material. And also we are varying inside cooling fluid Hydrocarbon (HC) and Hydro chloroflouro carbon (HCFC). The best material and best fluid for the evaporator of our design can be checked by comparing the results. Thermal analysis is done in ANSYS. Finally result extracted from simulation is analyzed for its performance.

Keywords: Hydro chlorofluorocarbons, Hydrocarbons.

1. Introduction

An air conditioner (often referred to as AC) is a home appliance, system, or mechanism designed to dehumidify and extract heat from an area. The cooling is done using a simple refrigeration cycle.
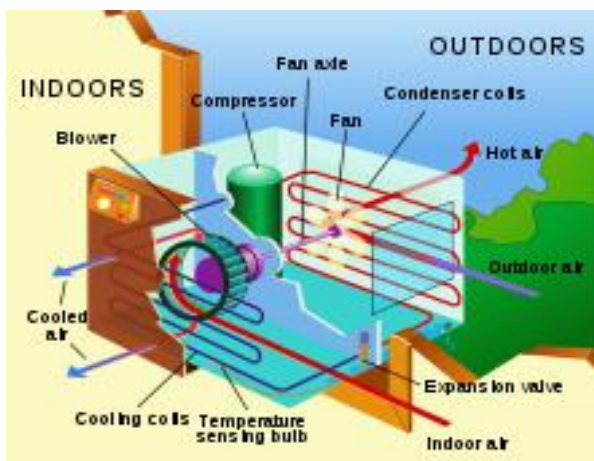

Fig 1 A typical home air conditioning unit

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In construction, a complete system of heating, ventilation and air conditioning is referred to as HVAC. Its purpose, in a building or an automobile, is to provide comfort during either hot or cold weather.
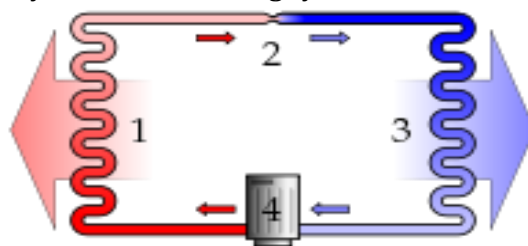
2. Theory of Air Conditioning System

Fig 2 Diagram of the refrigeration cycle: 1) condensing coil, 2) expansion valve, 3) evaporator coil, 4) compressor

In the refrigeration cycle, a heat pump transfers heat from a lower-temperature heat source into a higher-temperature heat sink. Heat would naturally flow in the opposite direction. This is the most common type of air conditioning. A refrigerator works in much the same way, as it pumps the heat out of the interior and into the room in which it stands.

This cycle takes advantage of the way phase changes work, where latent heat is released at a constant temperature during a liquid/gas phase change, and where varying the pressure of a pure substance also varies its condensation/boiling point.

The most common refrigeration cycle uses an electric motor to drive a compressor. In an automobile, the compressor is driven by a belt over a pulley, the belt being driven by the engine's crankshaft (similar to the driving of the pulleys for the alternator, power steering, etc.). Whether in a car or building, both use electric fan motors for air circulation. Since evaporation occurs when heat is absorbed, and condensation occurs when heat is released, air conditioners use a compressor to cause pressure changes between two compartments, and actively condense and pump a refrigerant around. A refrigerant is pumped into the evaporator coil, located in the compartment to be cooled, where the low pressure causes the refrigerant to evaporate into a vapor, taking heat with it. At the opposite side of the cycle is the condenser, which is located outside of the cooled compartment, where the refrigerant vapor is compressed and forced through another heat exchange coil, condensing the refrigerant into a liquid, thus rejecting the heat previously absorbed from the cooled space.

By placing the condenser (where the heat is rejected) inside a compartment, and the evaporator (which absorbs heat) in the ambient environment (such as outside), or merely running a normal air conditioners refrigerant in the opposite direction, the overall effect is the opposite, and the compartment is heated. This is usually called a heat pump, and is capable of heating a home to comfortable temperatures (25 °C; 70 °F), even when the outside air is below the freezing point of water (0 °C; 32 °F).

3. Thermal Analysis of Evaporator

3.1 Thermal Analysis of Evaporator using Copper for Tube and Plate by using Hydrocarbon Fluid

Input Parameters

Tube Material - Copper

Element Type: solid 20 nodes 90

Material Properties: Thermal Conductivity – 603w/m K

Specific Heat – 14 j/kg k

Density - 0.00007500 kg/mm^3

Plate Material - Copper

Element Type: solid 20 nodes 90

Material Properties: Thermal Conductivity – 603w/m K

Specific Heat – 14 J/kg k

Density - 0.00007500 kg/mm^3

Temperature – 16 ^{0}C

Heat flow – 2 kj/sec

Bulk Temperature – 10^{0}C
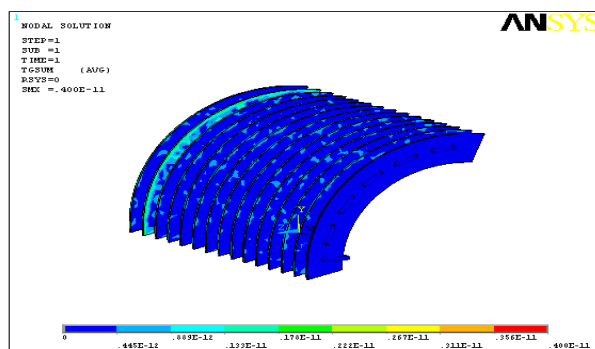
Film Coefficient – 900W/m^{2}K

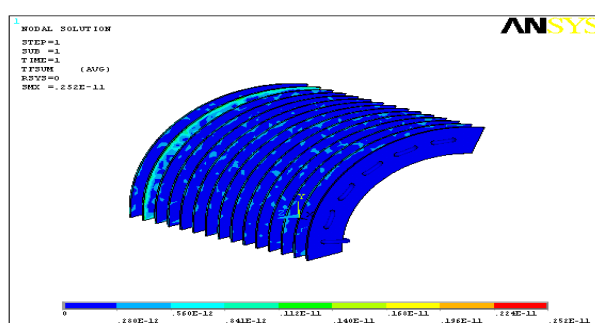**Fig 3** Thermal Gradient Vector sum Plot

Fig 4 Thermal flux vector sum plot

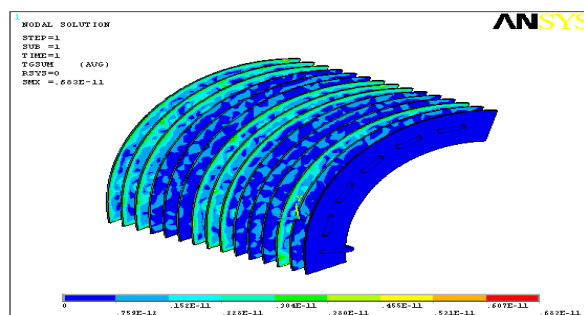*3.1.1 Thermal Analysis of Evaporator using Copper for Tube and Al [Al99] for Plate*

Fig 5 Thermal Gradient Vector sum Plot
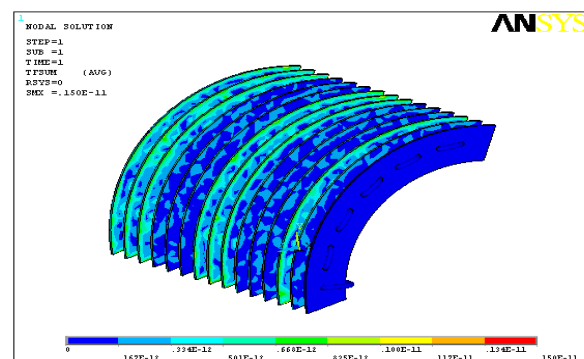

Fig 6 Thermal flux vector sum plot

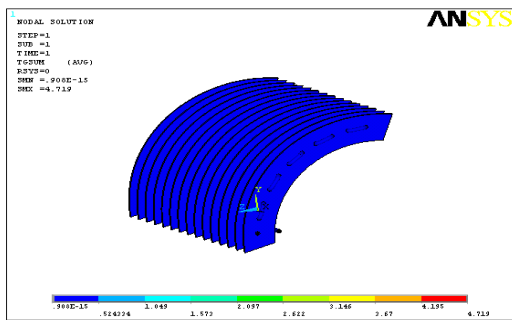*3.1.2Thermal Analysis of Evaporator using Copper for Tube and Al 204 for Plate*
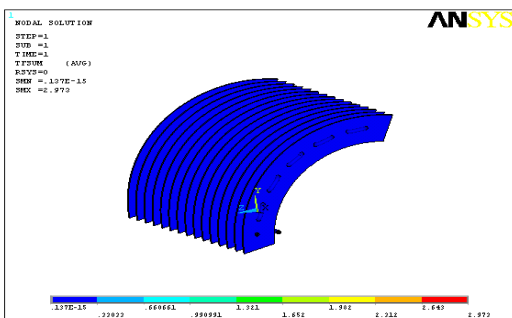

Fig 7 Thermal Gradient Vector sum Plot

Fig 8 Thermal flux vector sum plot

3.2 Thermal Analysis of Evaporator using Hydro chloroflouro carbon (HCFC).

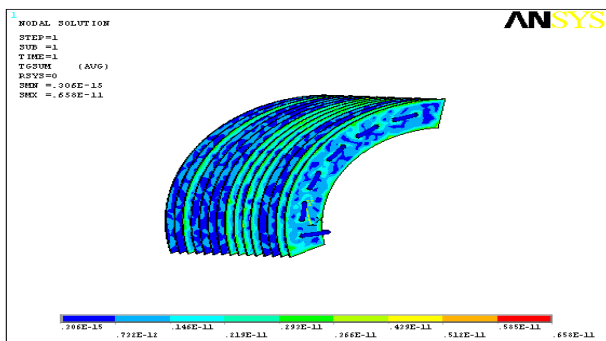*3.2.1 Thermal Analysis of Evaporator using Copper for Tube and Plate*

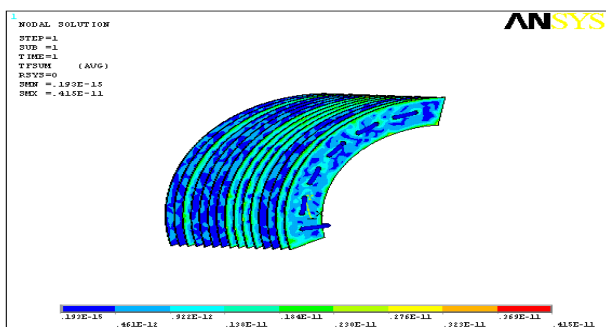
Fig 9 Thermal Gradient Vector sum Plot

Fig 10 Thermal flux vector sum plot

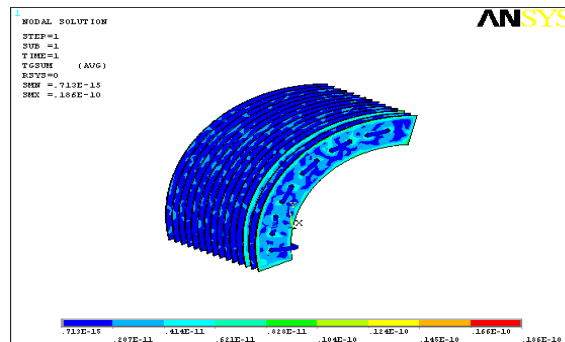*3.2.2Thermal Analysis of Evaporator using Copper for Tube and Al [Al99] for Plate*

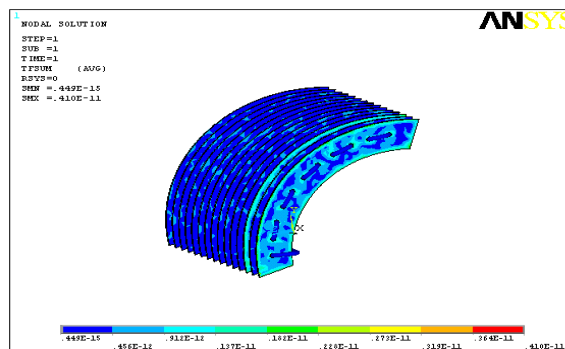**Fig 11** Thermal Gradient Vector sum Plot

Fig12 Thermal flux vector sum plot

3.2.2Thermal Analysis of Evaporator using Copper for Tube and Al 204 for Plate
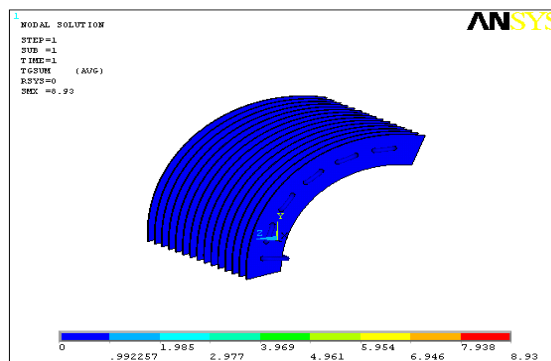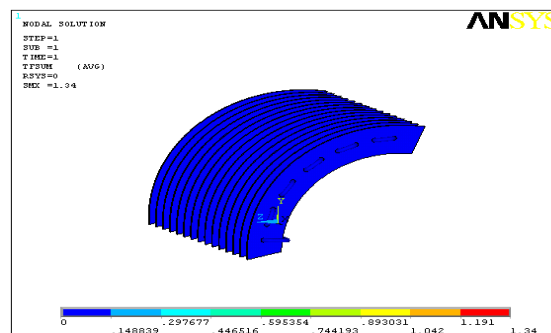

Fig 13 Thermal Gradient Vector sum Plot

Fig 14 Thermal flux vector sum plot

4. Results

Table 1 Thermal analysis for fluid Hydrocarbon

Combination	Nodal temperature (^{0}C)	Thermal Gradient (K/mm)	Thermal Flux (W/mm^2)
Copper Tube Copper Plate	16	0.4e^{-11}	0.252e^{-11}
Copper Tube Al 99 Plate	16	0.683e^{-11}	0.15e^{-11}
Copper Tube Al 204 Plate	16	4.719	2.973

Table 2 Thermal analysis for fluid Hydro fluorocarbon

Combination	Nodal temperature (^{0}C)	Thermal Gradient (K/mm)	Thermal Flux (W/mm^2)
Copper Tube Copper Plate	16	0.658e^{-11}	0.415e^{-11}
Copper Tube Al 99 Plate	16	0.186e^{-11}	0.41e^{-11}
Copper Tube Al 204 Plate	16	8.93	1.34

Conclusions

In the present research work the 3D modeling for an air-cooled evaporator for 1.5 ton air conditioner is done using Pro/Engineer.

The thermal analysis is performed on the evaporator by taking tube material as copper and varying the plate materials, Copper, Al99, Al204. The analysis is also done by varying refrigerant Hydrocarbon and Hydro fluorocarbon.

In thermal analysis, the thermal properties like nodal temperature, thermal gradient and thermal flux are found out.

The result shows that the thermal gradient as well as thermal flux is more with the combination of Copper tube and Al 204 plate.

When comparing Hydrocarbon and Hydro fluorocarbon, using Hydro fluorocarbon is more advantageous since its thermal gradient is more with all combinations.

The nodal temperature is constant in all the combinations with Hydrocarbon and Hydro fluorocarbon fluids.

References

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