Modelling and Thermal Analysis of Air Conditioner Evaporator

Hashim Sahar Mohaisen, Dr. E. Ramjee

1PG Scholar, Dept of Mechanical Engineering, JNTUH College of Engineering (Autonomous), Hyderabad, India, & Republic of Iraq council of Ministries Shia Endowment Head office, E-mail: hsm197948@yahoo.com.
2Professor, Dept of Mechanical Engineering, JNTUH College of Engineering (Autonomous), Hyderabad, India, E-mail: e_ramjee@yahoo.com.

Abstract: Air conditioning evaporator works by absorbing heat from the other fluid such as brine & water or air that is to be cooled. It does that by maintaining the evaporator coil at low temperature and pressure than the surrounding air. In this project, the modeling and thermal analysis of an air-cooled evaporator for 1.5 ton air conditioner are done. In this project, the material used for coils is pure copper and the material used for fins are pure copper, brass or Aluminum with different alloy whose thermal conductivity is more than 200 w/m.k. Three models for an Air-conditioner evaporator were modeled using Pro-Engineer version 5.0 for the design of components (coil pipes, plate fins and then assembly) which have different in tube pitch, fin thickness and fin pitch. The Thermal Analysis of the three models has been carried out by using ANSYS WORKBENCH version 15.0 software. In thermal Analysis, the thermal properties are analyzed like nodal temperature, heat flux and direction of heat flux. The Thermal Analysis of the three models has been carried out by using various inside cooling fluids (Refrigerant) like R12 as Chlorofluorocarbons Refrigerant (CFC), R22 as Hydrochlorofluorocarbon Refrigerant (HCFC) and R134a as Hydrofluorocarbons Refrigerant (HFC) and also fins material is varied as pure copper, copper-Zink(brass), AL-1050 and AL-1100. The results obtained from the analysis of each model are expressed in the figures for nodal temperature and heat flux for different fin materials and refrigerants. The best material and best fluid for the evaporator of the design are checked by comparing the results. Comparison among the three results obtained from the analysis for each refrigerant are expressed in the figures for nodal temperature and heat flux for different fin materials to see the effect of tube pitch, thickness and pitch of the fin.

Keywords: CFC, HCFC, HFC, Meshing, Thermal Analysis.

I. INTRODUCTION

The evaporator is one of the four basic and necessary hardware components of the refrigeration system as shown in the Figure (1.1). (The refrigerant may be considered as a fifth, most important, component.) Depending on the application the design of the evaporator will differ. In the first part of this chapter different types of evaporators are presented and their applications discussed. The presentation will then focus on methods for calculating heat transfer and pressure drop, both on the refrigerant side and on the heat source side of the evaporator. Knowledge of such methods is necessary when sizing and designing refrigeration systems. Methods of enhancing heat transfer, on the refrigerant side as well as on the heat source side are then discussed briefly. Finally, a few words are spent on design optimization of evaporators. It should be noted that what is presented in this chapter concerning the calculation of heat transfer and pressure drop on the heat source side of the evaporator is generally also applicable to the heat sink side of condensers. As an introduction to the treatment of evaporators it is appropriate to recapitulate the physical processes involved. In the evaporator, the refrigerant is evaporated by the heat transferred from the heat source. The heat source may be a gas or a liquid or, e.g. in food freezers, a solid. During evaporation, the temperature of a pure refrigerant is constant, as long as the pressure does not change.

The basic temperature profile through an evaporator with liquid or gas phase heat source is therefore as shown in Figure (1.2). As shown, the temperature of the refrigerant must be below that of the heat source. This low refrigerant temperature is attained as a result of the reduction in pressure caused by the compressor: When the compressor is started and the pressure reduced, the equilibrium between liquid and vapour in the evaporator is disturbed. To re-establish equilibrium, more vapour is formed through evaporation of liquid. The heat of vaporization necessary for this is taken from the liquid itself, and therefore the liquid temperature drops. As heat starts to flow from the heat source, a new equilibrium temperature is established. In the evaporator there is thus a balance between the heat transferred to it due to the temperature difference between
the evaporator and the surroundings, and the heat transferred from it in the form of heat of vaporization of the vapour drawn into the compressor.

Devendra A. Patel et al (5) observed that: i) Case-I shows calculation for actual readings and case-II shows calculation for simulation when inlet temperature of oil & cooling water are kept unchanged. ii) As the outlet temperature of oil is 1 degree less in case-H die values of heat transfer rate, overall heat transfer co-efficient & effectiveness are higher for case-II compared to the case-I. iii) Case-II, III & IV shows the calculation and results for simulation readings. The cooling water inlet temperature is gradually decreased by 2 degree in each case. iv) As the temperature difference between oil inlet temperature and water inlet temperature, becomes larger, the values of Qmax increases. This is why. The heat transfer rate, overall heat transfer co-efficient and effectiveness is higher in case-in and case-VI compared to case-II. Derya Burcu Ozkan et al (6) examined parameters affecting the frost formation on the evaporator of a refrigerator and the structure of frost. Air velocity measurements both at the air inlet and outlet channels of the evaporator were performed, and the effect of an- velocity on frost Formation was examined. Qi Fan et al (7) said that the numerical simulations of dimple jacket constructions were performed by a computational fluid dynamics (CFD) program FLUENT in this work.

The effects of geometrical parameters such as cone angle, arrangement, interval and height of dimple on heat transfer and pressure drop of dimple jackets in thin-film evaporator were investigated numerically. Taijong Sung et al (8) presented an optimal design of a micro evaporator, to maximize the heat transfer coefficient (HTC) and it forms the starting point in developing miniaturized vapor compression refrigeration system. The experimental design is adopted to determine the optimal parameters of the evaporator for realizing the inlet-outlet conditions of the refrigerating cycle, and for increasing the HTC. Sangrok Jin et al (9) presented an optimal design for an orifice in a small cooler The objective of the optimal design is to maintain constant superheat at the outlet of an evaporator while the flow rate and cooling load are changed. T. Sriveerakul et al (10) investigated the use of CFD in predicting performance of a steam ejector used in refrigeration applications.

III. MODLING BY USING PRO-ENGINEER
After Getting Experimental data, the modeling has been performed on the PRO-ENGINEER version 5.0 and then after the analysis work has been performed on the ANSYS 15.0 version.

<table>
<thead>
<tr>
<th>TABLE I:</th>
</tr>
</thead>
<tbody>
<tr>
<td>No.</td>
</tr>
<tr>
<td>MODEL1</td>
</tr>
<tr>
<td>MODEL2</td>
</tr>
<tr>
<td>MODEL3</td>
</tr>
</tbody>
</table>
Modelling and Thermal Analysis of Air Conditioner Evaporator

Meshing:

Ansys for Model:
IV. RESULT

By observing the results for all cases, the following conclusions were drawn from the analysis:

For Use R12 as A Cooling Refrigerant:
- The First model gives maximum heat flux with fin made up of pure copper which is about 1.98E+05 W/m².
- The second model gives maximum heat flux with fin made up of pure copper which is about 2.62E+05 W/m².
- The Third model gives maximum heat flux with fin made up of pure copper which is about 1.77E+05 W/m².

For Use R22 as A Cooling Refrigerant:
- The First model gives maximum heat flux with fin made up of pure copper which is about 2.05E+05 W/m².
- The second model gives maximum heat flux with fin made up of pure copper which is about 2.60E+05 W/m².
- The Third model gives maximum heat flux with fin made up of pure copper which is about 1.78E+05 W/m².

For Use R134a as a Cooling Refrigerant:
- The First model gives maximum heat flux with fin made up of pure copper which is about 1.10E+05 W/m².
- The second model gives maximum heat flux with fin made up of pure copper which is about 1.60E+05 W/m².
Modelling and Thermal Analysis of Air Conditioner Evaporator

- The Third model gives maximum heat flux with fin made up of pure copper which is about 1.17E+05 W/m².

VI. REFERENCES

19. Tested Solutions to Design Problems in Air Conditioning and Refrigeration by M. A. Ramsay. The Industrial Press 1963 (Table 3.1 to 3.4).
20. Blue Star Engineers' Handbook (Different coil geometry).
21. Voltas Engineers' Handbook (Table 3.5).

Author's Details:

Hashim Sahar Mohaisen, received his bachelor degree in mechanical engineering (Refrigeration and Air conditioning specialization) from university of technology - Baghdad - Iraq. Presently he finished his master of technology in thermal engineering in Jawaharlal Nehru Technological University, Hyderabad, India. His research interest.

Dr. E. Ramjee, Professor of Mechanical Engineering Areas of Interest: IC. Engines, Fuels, Combustion and Environment, Thermal Engineering, Jawaharlal Nehru Technological University, Hyderabad, India.