**International Journal of Research**
**Available at https://edupediapublications.org/journals**

**e-ISSN: 2348-6848**
**p-ISSN: 2348-795X**
**Volume 05 Issue 15**
**May 2018**

# Thermal Analysis of AC Condenser Coil

Chavan Karthik & Dr. M. Naveen Kumar

[1]*M.Tech, Thermal Engineering, Siddhartha Institute of Technology and Sciences.*

[2] *Professor, Department of Mechanical Engineering, Siddhartha Institute of Technology and Sciences.*

**Abstract** - *A refrigeration and air conditioning engineer works on commercial, residential, public and industrial projects, including transportation and storage. Refrigeration is a process of removing heat from a low-temperature reservoir and transferring it to a high-temperature reservoir. The work of heat transfer is traditionally driven by mechanical means, but can also be driven by heat, magnetism, electricity, laser, or other means. Refrigeration has many applications, including, but not limited to: household refrigerators, industrial freezers, cryogenics, and air conditioning.*

*In systems involving heat transfer, a condenser is a device or unit used to condense a substance from its gaseous to its liquid state, by cooling it. In so doing, the latent heat is given up by the substance and transferred to the surrounding environment. Condensers can be made according to numerous designs, and come in many sizes ranging from rather small (hand-held) to very large (industrial-scale units used in plant processes).*

*In this project we will design condenser tubes with proper dimensions. The material of tubes is made up of copper and fins are varying with different materials like Aluminum 1100 and Aluminum 1050.The refrigerants varied will be R 12, R 22 and R134. The refrigerants are Heat transfer analysis done on condenser by using ANSYS CFD (Fluent) and modeling of the condenser tubes is done in SOLIDWORKS. CFD Fluent is used for to determine the heat transfer rate, temperature and velocity of refrigerant flow.*

**Keywords**:Ac Condenser, CFD, Refrigerants,Coefficient of performance (COP).

## 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. In construction, a complete system of heating, ventilation and air condition ing is referred to as “HVAC”. Its purpose, in a building or an automobile, is to provide comfort during either hot or cold weather.

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 runnng 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). Cylinder un loaders are a method of load control used mainly in commercial air conditioning systems. On a semi-hermetic (or open) compressor, the heads can be fitted with unloaders which remove a portion of the load from the compressor so that it can run better when full cooling is not needed. Unloaders can be electrical or mechanical.

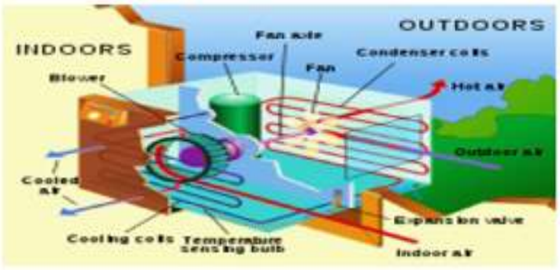

Figure 1: Image of A typical home air conditioning unit

## APPLICATIONS

Air cooled –If the condenser is located on the outside of the unit, the air cooled condenser can provide the easiest arrangement. These types of condensers eject heat to the outdoors and are simple to install.

Most common uses for this condenser are domestic refrigerators, upright freezers and in residential packaged air conditioning units. A great feature of the air cooled condenser is they are very easy to clean. Since dirt can cause serious issues with the condensers performance, it is highly recommended that these be kept clear of dirt.

- Water cooled –Although a little more pricey to install, these condensers are the more efficient type. Commonly used for swimming pools and condensers piped for city water flow, these condensers require regular service and maintenance.

They also require a cooling tower to conserve water. To prevent corrosion and the forming of algae, water cooled condensers require a constant supply of makeup water along with water treatment.

Depending on the application you can choose from tube in tube, shell and coil or shell and tube condensers. All are essentially made to produce the same outcome, but each in a different way.

- Evaporative –While these remain the least popular choice, evaporative condensers can be used inside or outside of a building and under typical conditions, operate at a low condensing temperature.

Typically these are used in large commercial air-conditioning units. Although effective, they are not necessarily the most efficient.

## 2. LITERATURE REVIEW

The majority of the research work focused large chillers. But in this paper discusses the single split air conditioning system using instead of air coolingusingliquid based cooling. The coolant used in the heat exchanger pure ethylene glycol. Compare the experimental results value of existing system with new modified system. The compressor running time for the pure ethylene glycol based cooling system is less than the existing system. The compressor'srunning time is reduced from 44 minutes 30 seconds to 33 minutes and 4 seconds. The required indoor temperature of 18°C is reached in 11 minutes 26seconds earlier. It is evident that the time taken for cooling by the modified system is 25.69 % less than that of the existing split air condition system. Timetaken for cooling reduces automatically improve the efficiency of the air conditioning system.

In order to increase the performance of air conditioner, one of the best solutions is decreasing the condenser temperature. Reducing the condenser temperature reduces the pressure ratio across the compressor which results power consumption reduction. It also decreases the refrigerant quality after the capillary tube and more liquid refrigerant would be available in the evaporator, therefore mass flow rate of refrigerant and the cooling capacity ofthe refrigerant are increased. To reduce the condenser temperature, one of the easiest ways is the application of direct evaporative cooler in front of the condenser to cool down the air temperature before it passes over the condenser. Using evaporative cooler in front of the air condenser can be considered as energy efficient, environmentfriendly and cost-effective method to enhance the performance of air conditioners. Since huge numbers of air conditioners are used in the residential sector, therefore, any considerable improvement in the

performance of the cycle will have huge effect on the power consumption of the whole network.
S.S. Hu and B.J. Huang investigated of a high-efficiency split residential water cooled air conditioner that utilizes cellulose pad as the filling material of the cooling tower. The cooling tower performance is improved due to good water wet ability of the cellulose pad that causes a uniform water film over the entire surface of the pads and aperfect contact between water and cooling air. The cooling tower is integrated with the condensing unitof the Rankine cycle in structure design to form anvintegral-type outdoor unit. The heat and mass transfer characteristics of the cellulose pads is first studied and the results are used for the design of the cooling tower. A prototype with 3.52 kW cooling capacity was constructed and tested in the present study. The experimental results show the coefficient of performance (COP) reaches 3.45 at wet-bulb temperature 27 °C, dry-bulb temperature 35 °C, air velocity 1.7 m/s, water flow rate 5.1 l/min, and that is higher than the standard value (2.96) of thoseconventional residential split air conditioners.

With the advent of computers, the study of various components of a domestic air conditioning system under a range of operating conditions has become possible through mathematical modeling, saving thus a huge amount of time and money. Subsequently, simulation of an air conditioning system demands a thorough knowledge on simulation techniques. Hence an elaborate literature survey has been conducted and it is presented in this section.
Corberan et al (2004) predicted a model to calculate the mass flow rate of refrigerant in a capillary tube by means of the conservation equations (mass, momentum and energy) over individual control volumes and included in IMST-ART, software for simulation and design of refrigeration equipment. The addition of capillary tube model allows calculating the superheat at the evaporator giving the capillary tube geometry. A simulation with different operative conditions and capillary geometry is done and the results are compared for R22 with those given by ASHRAE correlations.

## 3. METHODOLOGY

### 3.1 Methodology

The idea behind the proposed system is to design optimization technique that can be useful in assessing the best configuration of a finned-tube condenser. Heat transfer by convection in air cooled condensers. Modeling is done in Pro/Engineer. Heat transfer analysis is done on the con denser to evaluate the material and refrigerant. The materials considered for tubes are Copper and Aluminum alloy 1100 and for fins are 1050 and 1100. The refrigerants varied are R12, R 22 and R 134. 3D modeling is done in Pro/Engineer and analysis is done in Ansys.
Air cooled condensers are used in small units like household refrigerators, deep freezers, water coolers, window air-

conditioners, split air-conditioners, small packaged air-conditioners etc. These are used in plants where the cooling load is small and the total quantity of the refrigerant in the refrigeration cycle is small. Air cooled condensers are also called coil condensers as they are usually made of copper or aluminum coil. Air cooled condensers occupy a comparatively larger space than water cooled condensers. In the present work, the performance analysis of air cooled condensing unit has been carried out by varying the fin material and fin thickness. At present aluminum alloy 204 is being used for fins.

Two fin materials namely, Aluminum alloys 1100 and 1050were considered to study the effect of fin's thermal conductivity on the performance of the condenser. Pro Engineer is used to model the system. For thermal analysis purpose ANSYS Works software is used. Considering different factors for a condenser, such as heat transfer, density etc., and Aluminum alloy 1100is found to be the best fin material.

Material properties of Aluminum 1050

| Property | Value |
|---|---|
| Density | 2.71 g/m³ |
| Melting Point | 650°C |
| Modulus of Elasticity | 71 GPa |
| Thermal Conductivity | 222 W/m.K |
| Thermal Expansion | 24x10$^{-6}$ /K |

Material properties of Aluminum 1100

| Property | Value |
|---|---|
| Density | 2.71 g/cm³ |
| Melting Point | 689 °C |
| Modulus of Elasticity | 74 GPa |
| Thermal Conductivity | 218 W/m.K |
| Thermal Expansion | 23.6 x10$^{-6}$ /K |

## 3.2 DESIGN AND MODELLING OF ENVIRONMENT TEST CHAMBER

PRO/ENGINEER offers a solution to shape design, styling, surfacing workflow and visualization to create, modify, and validate complex innovative shapes from industrial design to Class-A surfacing with the ICEM surfacing technologies. PRO/ENGINEER supports multiple stages of product design whether started from scratch or from 2D sketches. PRO/ENGINEER is able to read and produce STEP format files for reverse engineering and surface reuse

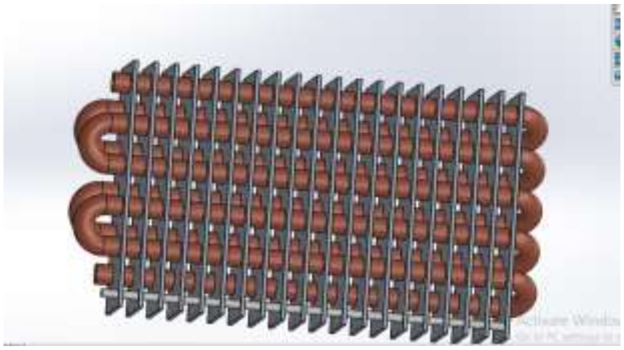

**Figure 2: Sketcher of condenser coil**

## Results of Aluminum alloy 1100

### Temperature

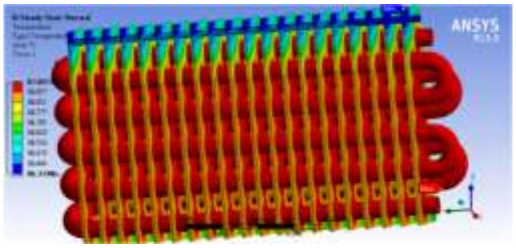

**Figure 3: Temperature**

### Total Heat Flux

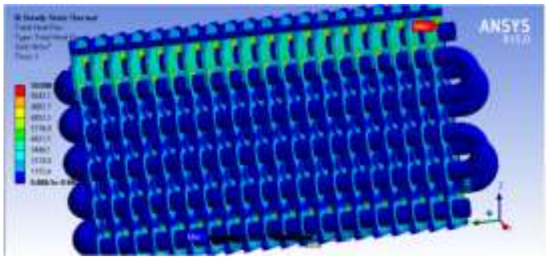

Figure 4:Total heat flux

## Results of Aluminum alloy 1050

### Temperature

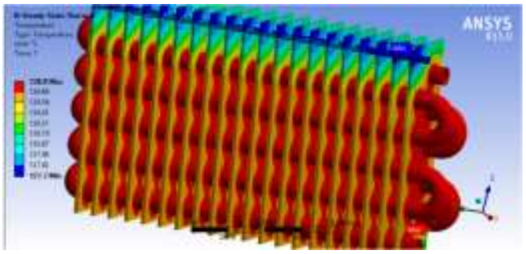

Figure 5: Temperature

### Total Heat Flux

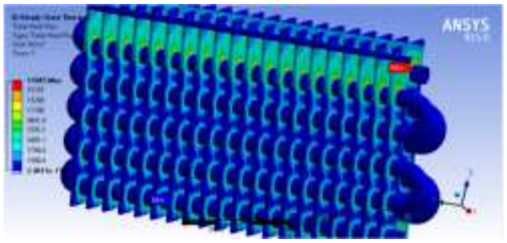

Figure 6:  Total heat flux

## The Methodology Followed In The Project Is As Follows:

- Create a 3D model of the ac condenser assembly using parametric software pro-engineer.
- Convert the surface model into Para solid file and import the model into ANSYS to do analysis
- Perform thermal analysis on the ac condenser assembly for thermal loads.
- Perform CFD analysis on the existing model of the surface ac condenser for Velocity inlet to find out the mass flow rate, heat transfer rate, pressure drop.

## 4. RESULTS AND DISCUSSIONS

### CFD analysis

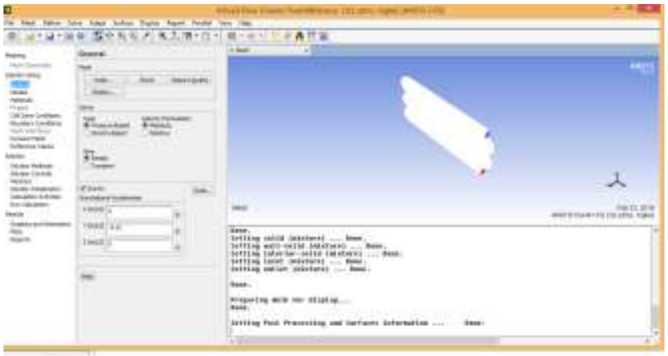

Figure 7: setup for cfd

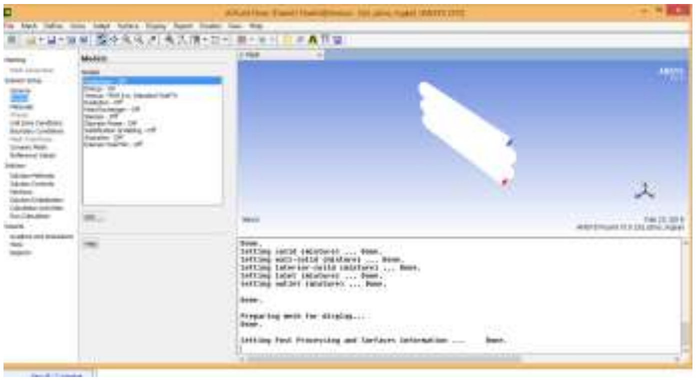

Figure 8: Model boundary conditions

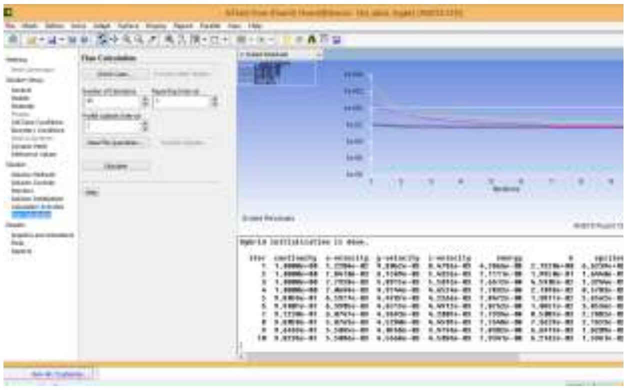

**Figure 9: Run calculations**

## 5. CONCLUSION

In this thesis heat transfer by convection in AC by varying the refrigerants are determined by CFD and thermal analysis. The assessment is out on an air-cooled tube condenser of a vapor compression cycle for air conditioning system. The materials considered for tubes are Copper and material considered for fins are Aluminum alloys 1100 and 1050. The refrigerants varied will be R 12, R 22 and R134. CFD analysis is done to determine temperature distribution and heat transfer rates by varying the refrigerants. Heat transfer analysis is done on the condenser to evaluate the better material. From the analysis results, the heat transfer rate is more when refrigerant R22 is used since heat flux is more.. When compared the results for fin material between Aluminum alloy 1100 and 1050, using Aluminum alloy 1050 is better. Heat transfer analysis is done on the condenser to evaluate the material and refrigerant.

## REFERENCES

[1]Experimental Investigation of Split air Conditioning System by liquid Based Cooling System by Balaji N, Suresh Mohan kumarpefficient usage of waste heat from air conditioner by M. Joseph

[2]Stalin, S. Mathana Krishnan, G. Vinoth Kumar

[3]Comparitive analysis of an automotive air conditioning systems operating with CO2 and R134a by J. Steven Brown a, Samuel F. Yana-Motta b,Piotr A. Domanski c

[4]Performance Enhancement of Air-cooled Condensers by M. M. Awad , H. M. Mostafa , G. I. Sultan , A. Elbooz

[5]S.H. Noie-Baghban, G.R. Majideian, “Waste heat recovery using heat pipe heat Exchanger (HPHE) for surgery rooms in hospitals”, Applied Thermal Engineering, Vol. 20, (2000) 1271-1282.

[6]P.Sathiamurthi, R.Sudhakaran “Effective utilization of waste heat in air conditioning. Proc. (2003) 13-14.

[7]P. Sathiamurthi, PSS.Srinivasan, design and development of waste heat recovery system for air conditioner, European Journal of Scientific Research ISSN 1450-216X Vol.54 No.1 (2011), Pp.102- 110.

[8]N.Balaji, P.Suresh Mohan Kumar, Eco friendly Energy Conservative Single window Air Conditioning System by Liquid Cooling with helical inter cooler ISSN 1450-216X Vol.76 No.3 (2012), pp.455-462.

[9]S.C.Kaushik, M.Singh.“Feasibility and Refrigeration system with a Canopus heat exchanger”, Heat Recovery Systems & CHP, Vol.15 (1995)665 - 673.

[10]R.TugrulOgulata, “Utilization of waste-heat recovery in textile drying”, Applied Energy.

[11]A mathematical model of a steam condenser inoff-design operation by RafałMarcinLaskowski, Journal of Power Technologies 92 (2) (2012) 101–108.

[12] Performance analysis of finned tube air cooled con-densing unit of split air conditioner by B. Sreelakshmi, Advanced Engineering and Applied Sciences: An Inter-national Journal Universal Research Publications, ISSN 2320–3927

[13] Improving the Heat Transfer Rate for Ac Condenser By Material And Parametric Design Optimization by V Srividhya, G VenkateswaraRao, International Journal of Engineering Research & Technology, Vol.2 - Issue 1 (January - 2013), e-ISSN: 2278-0181