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Parametric Optimization of A.C Condenser by Varying Refrigerants and Materials

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ABSTRACT:

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 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 Aluminum alloys 1060 and 1100. The refrigerants varied will be R 12, R 134 and R407C. 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.3D modeling is done in Pro/Engineer and analysis is done in Ansys.

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 conditioning is referred to as "HVAC". Its purpose, in a building or an automobile, is to provide comfort during either hot or cold weather.

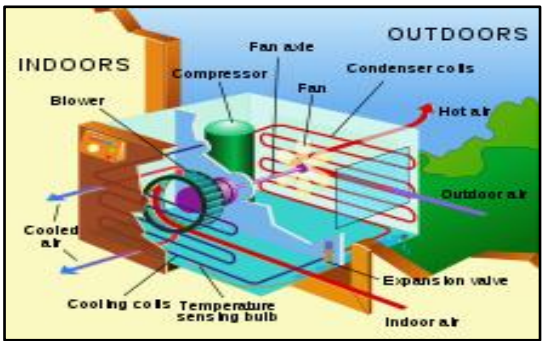

Fig. 1.1 A typical home air conditioning unit.

1.1Air Conditioning System Basics

A simple 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/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

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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.

1.2HUMIDITY

Air conditioning equipment usually reduces the humidity of the air processed by the system. The relatively cold (below the dew point) evaporator coil condenses water vapor from the processed air, much as a cold drink will condense water on the outside of a glass. The water is drained, removing water vapor from the cooled space and thereby lowering its relative humidity. Since humans perspire to provide natural cooling by the evaporation of perspiration from the skin, drier air (up to a point) improves the comfort provided. The comfort air conditioner is designed to create a 40% to 60% relative humidity in the occupied space. In food retail establishments, large, open chiller cabinets act as highly effective dehumidifiers.

1.3REFRIGERANTS

"Freon" is a trade name for a family of haloalkane refrigerants manufactured by DuPont and other companies. These refrigerants were commonly used due to their superior stability and safety properties. However, these chlorine-bearing refrigerants reach the upper atmosphere when they escape. Once the refrigerant reaches the stratosphere, UV radiation from the Sun cleaves the chlorine-carbonbond, yielding chlorineradical. These chlorine atoms catalyze the breakdown of ozone into diatomicoxygen, depleting the ozone layer that shields the Earth's surface from strong UV radiation.

1.4CENTRALAIR CONDITIONING SYSTEM

Central air conditioning, commonly referred to as central air (U.S.) or air-con (UK), is an air conditioning system that uses ducts to distribute cooled and/or dehumidified air to more than one room, or uses pipes to distribute chilled water to heat exchangers in more than one room, and which is not plugged into a standard electrical outlet.

1.5 INTRODUCTION TO CONDENSER

A condenser or evaporator is a **heat exchanger, allowing condensation**, by means of giving off, or taking in heat respectively. Refrigerant and air will be physically separated, at air conditioner condenser, and evaporator. Therefore, heat transfer occurs by means of conduction. We would like the heat exchanger that enables these processes, to have,

- High conductivity– this property will ensure that the low temperature difference between the outside wall, and inside wall
- High contact factor– this property ensures the passing air mass, will come in contact with the tubes, as much as possible

1.6 CONTACT FACTOR

It is the amount of media that needs to be heated up or cooled down, that comes directly in contact with the tube walls. Contact factor will be very low, if the air inside a duct is passed through a straight tube with refrigerant. This happens as the amount of air that contacts the tube will be very low.

Therefore, we will increase the contact factor, by constructing the condenser and evaporator to have many passes within a given duct area. Thus, the passing air will “see” a lot of tubes on its passage. Hence the contact factor will be improved

2. LITERATURE SURVEY

Balaji Netal,the majority of the research work focused large chillers. But in this paper discusses the single split air conditioning system using instead of air cooling using liquid based cooling. The coolant used in the heat exchanger pure ethylene glycol. Compare the

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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's running 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. Time taken for cooling reduces automatically improve the efficiency of the air conditioning system.

M. Joseph Stalinet, as the energy demand in our day to day life escalates significantly, there are plenty of energies are shuffled in the universe. Energies are put in an order of low grade and high grade energies. The regeneration of low grade energy into some beneficial work is fantastic job. One such low grade energy is heat energy. So it is imperative that a significant and concrete effort should be taken for using heat energy through waste heat recovery. This paper concentrates on the theoretical analysis of production of hot water and reduction of LPG occupies most of our condominium for our comforts. An attempt has been taken to recover waste heat rejected by the 1 TR air conditioning systems. For this water cooled condenser is exerted and the water is promulgated by until our desired temperature is acquired. Then the hot water is accumulated in insulated tank for our use. The result of the paper shows that the temperature of hot water, time required for attaining that temperature for the necessary volume of water and the reduction of LPG gas by using hot water is also confabulated. Factors like supply and demand, condenser coil design are pondered and theoretically calculated and the corresponding graphs are drawn. Finally this could be the surrogate for water heater and it fulfils all the applications of Hot water. Similarly, it could tackle the demand of LPG gas.

S.H. Noie-Baghban, Research has been carried out on the theory, design and construction of heat pipes, especially their use in heat pipe heat exchangers for energy recovery, reduction of air pollution and environmental conservation. A heat pipe heat exchanger has been designed and constructed for heat recovery in hospital and laboratories, where the air must be changed up to 40 times per hour. In this research, the characteristic design and heat transfer limitations of single heat pipes for three types of wick and three working fluids have been investigated, initially through computer simulation. Construction of heat pipes, including washing, inserting the wick, creating the vacuum, injecting the fluid and installation have also been carried out. After obtaining the appropriate heat flux, the air-to-air heat pipe heat exchanger was designed, constructed and tested under low temperature (15–55°C) operating conditions, using methanol as the working fluid. Experimental results for absorbed heat by the evaporator section are very close to the heat transfer rate obtained from computer simulation. Considering the fact that this is one of the first practical applications of heat pipe heat exchangers, it has given informative results and paved the way for further research.

M. M. Awad, Heat transfer by convection in air cooled condensers is studied and improved in, this work. In order to enhance the performance of air cooled condensers, it is important to take into consideration both of condensation inside condenser tubes and convection outside, where the enhancement in convection side is the dominant one. Aluminiumextruded micro-channel flat tubes improve the performance of condensation more than conventional circular tubes but still has potential for air side improving. So the enhancement of convective heat transfer in air side is achieved in this study by inclination of the flat tubes by a certain angle with respect to horizontal in two cases. The first proposed case is to make convergent and divergent channels for air flow (case 1), while the second case is tilting all tubes in parallel to each other (case 2). A parametric study is performed to investigate the optimum inclination angle (β) and aspect ratio (Ar). Mathematical modellingfor air cooled condensers was applied to aluminum flat tubes to study and evaluate

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these proposed two cases. A computational fluid dynamic software (CFD) is used to solve the problem.

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3. INTRODUCTION TO CAD

Computer-aided design (**CAD**), also known as **computer-aided design and drafting** (**CADD**), is the use of computer technology for the process of design and design-documentation. Computer Aided Drafting describes the process of drafting with a computer. CADD software, or environments, provides the user with input-tools for the purpose of streamlining design processes; drafting, documentation, and manufacturing processes. CADD output is often in the form of electronic files for print or machining operations. The development of CADD-based software is in direct correlation with the processes it seeks to economize; industry-based software construction, manufacturing, etc. CADD environments often involve more than just shapes. CAD may be used to design curves and figures in two-dimensional (2D) space; or curves, surfaces, and solids in three-dimensional (3D) objects.

3.1 INTRODUCTION TO CREO

Creo is the standard in 3D product design, featuring industry-leading productivity tools that promote best practices in design while ensuring compliance with your industry and company standards. Integrated Creo CAD/CAM/CAE solutions allow you to design faster than ever, while maximizing innovation and quality to ultimately create exceptional products. Customer requirements may change and time pressures may continue to mount, but your product design needs remain the same - regardless of your project's scope, you need the powerful, easy-to-use, affordable solution that Creo provides.

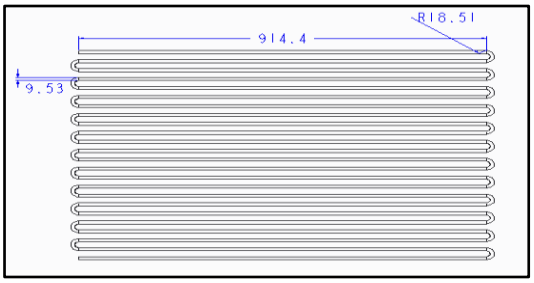

Fig. 1.2 – 2D Drafting

4. INTRODUCTION TO ANSYS

ANSYS is general-purpose finite element analysis (FEA) software package. Finite Element Analysis is a numerical method of deconstructing a complex system into very small pieces (of user-designated size) called elements. The software implements equations that govern the behaviour of these elements and solves them all; creating a comprehensive explanation of how the system acts as a whole. These results then can be presented in tabulated or graphical forms. This type of analysis is typically used for the design and optimization of a system far too complex to analyse by hand. Systems that may fit into this category are too complex due to their geometry, scale, or governing equations.

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4.1SPECIFIC CAPABILITIESOF ANSYS

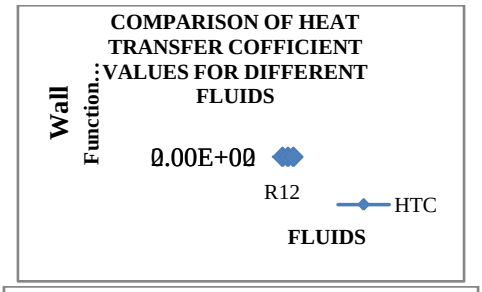
Structural analysis is probably the most common application of the finite element method as it implies bridges and buildings, naval, aeronautical, and mechanical structures such as ship hulls, aircraft bodies, and machine housings, as well as mechanical components such as pistons, machine parts, and tools.

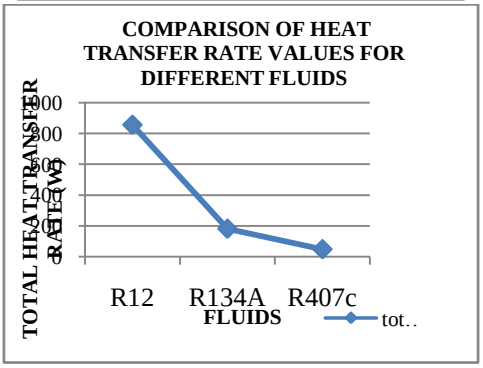
- Static Analysis.
- Transient Dynamic Analysis.
- Buckling Analysis.

5. CFD ANALYSIS

Computational Fluid Dynamics (CFD) provides a qualitative (and sometimes even quantitative) prediction of fluid flows. In this project CFD analysis is performed to obtain the heat transfer coefficient values for the selected three refrigerants R12, R134A, R407C.

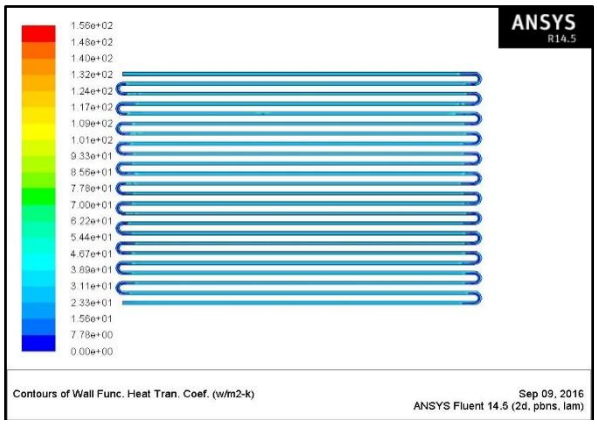
Fluids	Pressure (Pa)	Heat Transfer Coefficient (W/m^2-K)	Heat Transfer Rate (W)
R12	$3.12e^{+06}$	$1.08e^{+02}$	855.549
R134A	$3.37e^{+06}$	$1.56e^{+02}$	-181.78711
R407C	$1.52e^{+06}$	$1.47e^{+02}$	-48.704102





RESULTS

Heat Transfer Coefficient.



Heat Transfer Coefficient for fluid R134A

6. THERMAL ANALYSIS

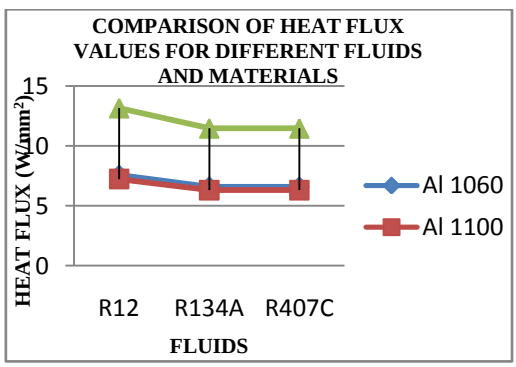
Thermal analysis is a branch of materials science where the properties of materials are studied as they change with temperature.

From the above obtained CFD results we perform thermal analysis for condenser for the selected three materials they are

1) Aluminum 1060
2) Aluminum 1100
3) Copper.

Materials	Fluids	Convection (W/m^2K)	Temperature (°C)	Heat flux (W/mm^2)
Aluminium 1060	R12	108	303.15	7.5558
	R134a	156	303.15	6.5842
	R407c	147	303.15	6.5831
Aluminium 1100	R12	108	303.15	7.2285
	R134a	156	303.15	6.2986
	R407c	147	303.15	6.2976
Copper	R12	108	303.15	13.137
	R134a	156	303.15	11.457
	R407c	147	303.15	11.454

Table 6.1 Thermal Analysis for Different Materials



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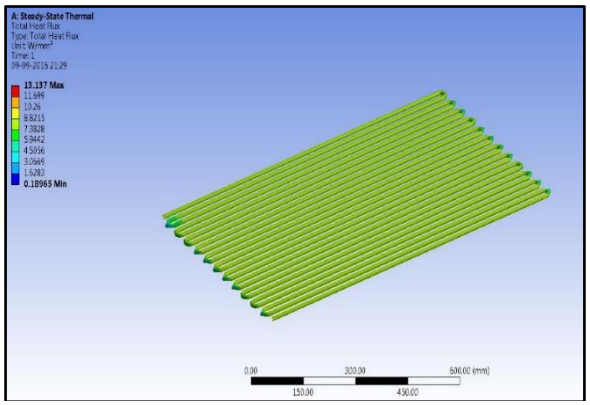
RESULTS

HEAT FLUX



Heat Flux for Copper Material for Fluid R12

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 vapour compression cycle for air conditioning system. The materials considered for tubes are Copper and Aluminum alloys 1060 and 1100. The refrigerants varied will be R 12, R 134 and R407C. 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. By observing CFD analysis results, the heat transfer coefficient is more when R134A is used and heat transfer rate is more when R12 is used than other fluids. By observing thermal analysis results, the heat flux is more when R12 is used and when material Copper is used. (i.e.) the heat transfer rate is more when fluid R134A and material Copper is used.

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