DESIGN AND HEAT TRANSFER ANALYSIS OF AC CONDENSER BY OPIMIZING MATERIAL

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ABSTRACT: Air conditioning systems have condenser that removes unwanted heat from the refrigerant and transfers that heat outdoors. Since, the AC condenser coil contains refrigerant that absorbs heat from the surrounding air, the refrigerant temperature must be higher than the air. In this the heat transfer by convection in AC is obtained 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. 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 CREO and analysis is done in ANSYS.

KEY WORDS: Heat transfer, condenser, copper, Aluminum alloy, refrigerant, heat flux.

I.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. A 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. . 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 the latent heat is given up by the substance, and will transfer to the condenser coolant.

Condensers are typically heat exchangers which have various designs and come in many sizes ranging from rather small (hand-held) to very large industrial-scale units used in plant processes. For example, a refrigerator uses a condenser to get rid of heat extracted from the interior of the unit to the outside air. Condensers are used in air conditioning, industrial chemical processes such as distillation, steam power plants and other heat-exchange systems. Use of cooling water or surrounding air as the coolant is common in many condensers. 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.).

Waste heat is generally the energy associated with the waste streams of air, gases and liquids that leaves the boundary of the system and enter into environment. The essential quality of heat is not the amount but its value. Waste heat recovery and utilization is the process of capturing and reusing waste heat for useful purposes. Not all waste heat is practically recoverable. The strategy of how to recover this heat depends on the temperature of the waste heat sources and on the economics involves behind the technology incorporated. Cooling generates considerable quantities of heat. If not utilized, this energy simply becomes waste heat. The cooling may be for the process cooling, air conditioning or other use. Vapor compression Refrigeration system is an improved type of air refrigeration system. The ability of certain liquids to absorb enormous quantities of heat as they vaporize is the basis of this system. Compared to melting solids (say ice) to obtain refrigeration effect, vaporizing liquid refrigerant has more advantages. To mention a few, the refrigerating effect can be started or stopped at will, the rate of cooling can be predetermined, the vaporizing temperatures can be governed by controlling the pressure at which the liquid vaporizes. Moreover, the vapor can be readily collected and condensed back into liquid state so that same liquid can be re-circulated over and over again to obtain refrigeration effect. Thus the vapor compression system employs a liquid refrigerant which evaporates and condenses readily. The System is a closed one since the refrigerant never leaves the system

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). 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.

II. LITERATURE SURVEY

In this by Jader R. Barbosa, etal, the purpose is to assess some aspects of the design of evaporators for household refrigeration appliances using Computational Fluid Dynamics (CFD). The evaporators under study are tube-fin 'no-frost' heat exchangers with forced convection on the air-side and a staggered tube configuration. The calculation methodology was verified against experimental data for the heat transfer rate, thermal conductance and pressure drop obtained for two evaporators with different geometries. The average errors of the heat transfer rate, thermal conductance and pressure drop were 10%, 3% and 11%, respectively. The CFD model was then used to assess the influence of geometric parameters such as the presence and position of the electrical heater coil relative to the tubes, the fin configuration and the width of the by-pass clearance between the outer edge of the fins and the tube bank for conditions typical of the design of household refrigeration appliances.

In the paper by Zine Aidoun, etal, almost all forced convection air coolers use finned tubes. Coils have in this way become established as the heat transfer workhorse of the refrigeration industry, because of their high area density, their relatively low cost, and the excellent thermo physical properties of copper and aluminum, which are their principal construction materials. Compact coils are needed to facilitate the repackaging of a number of types of air conditioning and refrigeration equipment: a reduced volume effectively enables a new approach to be made to the modular design and a route towards improving performance and size is through appropriate selection of refrigerants, heat transfer enhancement of primary and secondary surfaces through advanced fin design and circuit configurations. Circuiting, although practically used on an empirical basis, has not yet received sufficient attention despite its potential for performance improvement, flow and heat transfer distribution, cost and operational efficiency.

In the specific case of refrigeration and air conditioning, a confined phase changing refrigerant exchanges heat in evaporators with the cold room, giving up its heat. The design and operation of refrigeration coils is adapted to these particular conditions. Geometrically they generally consist of copper tubing to which aluminum fins are attached to increase their external surface area over which air is flowing, in order to compensate for this latter poor convection heat transfer. Coils generally achieve relatively high heat transfer area per unit volume by having dense arrays of finned tubes and the fins are generally corrugated or occasionally louvered plates with variable spacing and number of passes.

At the end, FEA analysis is carried out on it using ANSYS CFX, The result of analysis is compared with Experimental result. 3.7% variation found in both results. In the paper by Carles OLIET, etal, summarizes the research work carried out by the authors on domestic refrigerator no-frost evaporators. It includes an explanation of the experimental unit that is currently being constructed to test isobutene fin-and-tube evaporators, together with a short description of the numerical tools developed. The first preliminary experimental results using single-phase coolants are then given together with their numerical counterparts. The numerical results are presented in detail in order to both complementing the experimental information obtained, and to show its potential as an analysis and design tool. In the paper by Shun Ching Lee, behavior of cryogenic nitrogen in a room-temperature evaporator six meters long is analyzed. Trapezoid fins are employed to enhance the heat flux supplied by the environment.

The steady-state governing equations specified by the mixed parameters are derived from the conservations of momentum and energy. The initial value problem is solved by space integration. The fixed ambient conditions are confirmed by way of the melt back effect. An integrated model is utilized to analyze the convective effect of two-phase flow, which dominates the evaporation behavior. Another integrated model is employed to determine the total heat flux from the environment to the wet surface of the evaporator. The foundation of the formation of an ice layer surrounding the evaporator is presented. If the fin height is shorter than 0.5 m, the whole evaporator is surrounded by ice layer. If the fin height is longer than 0.5 m, the total pressure drop of nitrogen in the tube is negligible. The outlet temperature is always within the range between −12 °C and 16 °C for the evaporator with the fin height of 1.0 m.

III. RELATED WORK

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 condenser 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 6063were 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 COSMOS 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. A condenser or evaporator is a heat exchanger, allowing condensation, by means of giving off, or taking in heat respectively. Construction principle: Refrigerant and air will be physically separated, at air conditioner condenser, and evaporator. Therefore, heat transfer occurs by means of conduction. 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. The tube will have a circular wall. Fourier 'slaw has stated that the rate of conduction heat transfer is proportional to, the thermal conductivity of the wall k W/m2, the mean surface area, A m2 the inverse of the wall's thickness L in meters and the temperature difference between the inside wall, and the outside wall Selection of the tube for the condenser and evaporator has to meet few other criteria as well. It has to be durable, difficult to oxidize, easy to join with other lengths of similar tube, good strength and cheap. Copper and aluminum has proven time and time again, to meet all the criteria mentioned, with excellent thermal conductivity. It will imply that the rate of heat transfer will increase if the total surface area of the condenser's or the evaporator's is increased. Because most of the work done by the compressor will be converted into giving off, and taking in heat, we can have an insulator, if the temperature difference between the walls is high. In other words, we want the tube to be as "non-existent" as possible.

The length and size of air conditioner condensers and evaporators have to be sized such that, the refrigerant is completely condensed before the condenser's exit, and the refrigerant is completely boiled before the evaporator's exit those two, depends mainly on the size of the compressor and refrigerant used. Air conditioner manufacturers has to understand how conduction, as well as convection works, to design an effective, yet compact air conditioner condenser and evaporator, per unit heat transferred. Normally, the condenser and evaporator will be designed to 110% of the intended heat transfer requirement, to cater for any performance drop during the service life.

IV. PROPOSED METHOD

In this paper we have presented a design and analysis of heat transfer of an AC condenser for using different materials. Initially need to prepare the analysis and designs related to heat transfer using PRO/ENGINEER, Finite Element Analysis (FEA), and 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 aluminium coil. Air cooled condensers occupy a comparatively larger space than water cooled condensers. Unlike evaporative condensers, air-cooled condensers have a capacity which is related to the dry-bulb temperature of the ambient air, rather than to its wet-bulb temperature. If working condenser pressures are not to become excessively high, making the plant expensive to run, large condenser surface areas must be used. This has set a limit on the practical upper size of air-cooled condensers. Their use in air conditioning has been commonly confined to plants having a capacity of less than 70 kW of refrigeration, although they have been used for duties as high as 2000 kW, in temperate climates.

The hot gas discharged from the compressor is de superheated over approximately the first 5 per cent of the heat transfer surface, followed by condensation over the succeeding85 per cent, with a small drop in the condensing temperature, related to the frictional pressure loss. A certain amount of sub-cooling of the liquid can then occur. Additional heat transfer surface may be provided to assist the sub-cooling, achieving an increase of about 0.9 per cent in the cooling capacity for each degree of liquid temperature drop, according to ASHRAE (1996). Propeller fans, direct-coupled to split-capacitor driving motors, are most commonly used to promote airflow, although axial flow or centrifugal fans are also sometimes adopted. Fan powers are about 20 to 40 W for each kW of refrigeration capacity. Noise is often a problem and this is made worse if there are obstructions in the inlet or outlet airflow paths. Although vertical fan arrangements are possible, with horizontal cooling airflow paths, these are susceptible to wind pressures and it is recommended that the condenser coils should be horizontal with vertical cooling airflow paths.

Propeller fans will not deliver airflow against any significant external resistance. It follows that ducting connections are then not possible if these fans are used. A 20-degree difference between the entering dry-bulb temperature and the condensing temperature is often consistent with the avoidance of excessively large condenser surface areas. Air-cooled condensers are increasing in popularity because of the absence of water piping, the consequent simplicity of operation and the freedom from any health risk associated with the use of spray water. One objection to their use is that the capacity of the refrigeration plant does not gradually reduce as the ambient dry-bulb rises but ceases suddenly when the high pressure cut-out operates. A partial solution is to arrange for some of the compressor to be unloaded when the condensing pressure rises, before it reaches the cut-out point. Continued operation at a reduced capacity is then possible beyond the design ambient dry-bulb. It is a good plan to select air-cooled condensers to operate in an ambient temperature two or three degree higher than the design value chosen for the rest of the air conditioning system.

V. RESULTS

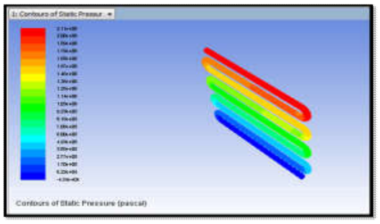

FIG. 1: PRESSURE

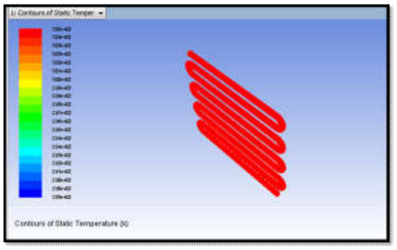

FIG. 2: TEMPERATURE

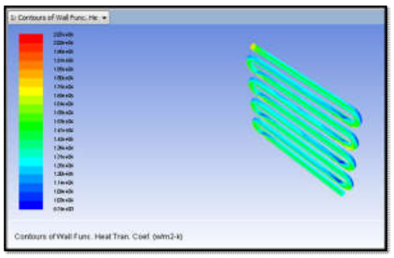

FIG. 3: HEAT TRANSFER COEFFICIENT

TABLE. 1: HEAT TRANSFER ANALYSIS OF CONDENSER

Mass flow rate (kg/s)	Condenser length(mm)	Pressure(Pa)	Temperature (K)	Heat transfer coefficient (W/mm²k)
1	R30	1.34e+06	3.05e+02	2.01e+04
	R160	1.43e+06	3.05e+02	2.04e+04
1.5	R30	2.15e+06	3.05e+02	1.83e+04
	R160	2.16e+06	3.05e+02	2.07e+04

VI. CONCLUSION

In condensers the refrigerant vapour condenses by rejecting heat to an external fluid, which acts as a heat sink. In evaporators, the liquid refrigerant evaporates by extracting heat from an external fluid (low temperature heat source). Condenser and evaporators modeling in solid works 3D modeling software and analysis in ANSYS software. CFD analysis to determine the heat transfer coefficient, heat transfer rate, mass flow rate and pressure drop for both models with different fluids (R30 &R160). By observing the CFD analysis of evaporator the heat transfer rate, heat transfer coefficient values are increases by increasing mass flow inlets. And maximum heat transfer coefficient value at the fluid refrigerant R160. So it can be concluded the refrigerant R160 fluid is giving better performance.

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