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Optimizing of Ac Condenser Using Refrigerants(Hcfc,R404) To Enhancing Heat Transfer Rate

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Abstract: In systems involving the heat transfer, a condenser is a device or entity used to condense a substance from its gaseous stage to its liquid stage, normally by cooling it. The latent heat is transfer by the substance, and will given up to the coolant of condenser. Condensers are normally heat exchangers which have different designs and many sizes varingfrom rather small to very large scale units used in the plant processes. 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 paper a optimization design technique that can be helpful in analysis the best layout of finned-tube condenser. In air cooled condensers the convection mode of heat transfer is studied and enhanced in this work. The analysis has been follow through on a vapour compression cycle system of air-cooled finned-tube condenser for air conditioning system. Heat transfer evalution and CFD evaluation is done on the condenser to assess the better design and material. The materials taken for fin is Al alloys 1100 & 6063 and magnesium and tube is copper for non-identical refrigerants HCFC &R404. 3D modeling is done in Pro/Engineer and evalution is done in Ansys.

Keywords: tubes, refrigerants, condenser, fins

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1.Introduction

An air conditioner Fig.1 (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.

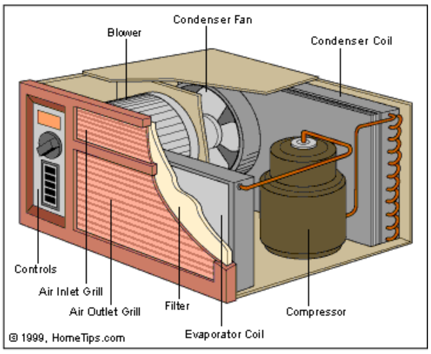
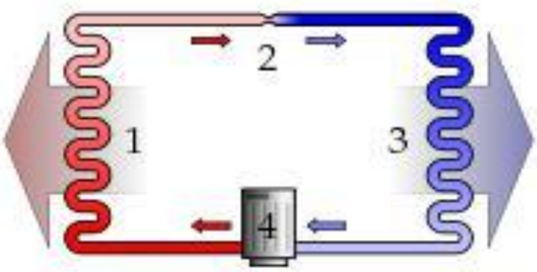


Figure : A typical home air conditioning unit

Air Conditioning System

Fig.2 shows A simple stylized diagram of the Refrigeration cycle: 1) condensing coil, 2) Expansion valve, 3) evaporator coil, 4) Compressor.



In this cycle, heat pump transfers heat from a lower-temperatureto higher-temperature (heat source-heat sink). Temperature naturally flow in higher body temperature to lower body temperature. This is regular type of air conditioning. A refrigerator works in similar way, it pumps the heat out of the evaporator and into the environment in which it stands.This cycle takes advantage of the way phase changes work, when latent heat released at constant temperature throught a liquid/gasstage change, where varying the pressure of a pure substance also varies its condensation/boiling point. 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 conditioner's 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).

Refrigerants

"Freon" is a name of haloalkane family refrigerants produced by DuPont& othercompanies. refrigerants are normally used due to their higher stability & safety properties.although, these cholofluoro carbons refrigerants reach the atmosphere when they get away(escape). Once the refrigerant reaches the stratosphere, UV radiation from the sun rays the chlorine-carbon bond, generate a chlorine radical. These catalyze chlorine atoms are the collapse of ozone into diatomic oxygen, reduce the ozone layer that shields the Earth's surface from strong UV radiation. Every chlorine radical remains active as a catalyst unless it bonds with another chlorine radical, forming a strong molecule and collapse the chain reaction.Use of CholoroFluoroCarbonsas a refrigerant was once normal, used in R-11 and R-12 refrigerants. Maximum in all countries CFCs manufacturing & usage has been restricted because ofworry about ozone depletion. All of these environmental concerns, From the November 14, 1994, the Environmental Protection Agency has restricted the sale, possession and use of refrigerant to only licensed technicians, per Rules 608 and 609 of the EPA rules and regulations; failure to comply may result in criminal and civil sanctions. Newer and more environmentally-safe refrigerants such as HCFCs (R-22, used in most homes today) and HFCs (R-134a, used in most cars) have replaced most CFC usage. HydroCholoroFluroCarbons are changed under the Montreal Protocol and replaced by (HFCs) hydro fluorocarbons such as R410A, which absence of chlorine. Carbon dioxide (R744) is being immediately taken as a refrigerant in Europe and Japan. R744 is an powerfull refrigerant with a global warming potential of 1. It required to use higher compression to produce an equivalent cooling effect.

Equipment capacity

Air conditioner equipment power in the U.S. is often described in terms of "tons of refrigeration". A "ton of refrigeration" is approximately equal to power of cooling of one short ton (2000 pounds or 907 kilograms) of ice melting in a 24-hour period. The value is defined as 12,000 BTU per hour, or 3517 watts. Residential central air systems are usually from 1 to 5 tons (3 to 20 kilowatts (kW)) in capacity.

unit size, BTU/h × hours per year, h × power cost, \$/kW·h ÷ (SEER, BTU/W·h × 1000 W/kW)

(72,000 BTU/h) × (1000 h) × (\$0.08/kW·h) ÷ [(10 BTU/W·h) × (1000 W/kW)] = \$576.00 annual cost

A common misconception is that the SEER rating system also applies to heating systems. However, SEER ratings only apply to air conditioning.

Insulation

In order to maintain building temperature, the air conditioning system must remove heat from the building during the cooling season, and add heat during the heating season. Insulation slows the speed at which heat is gained or lost, and therefore reduces the required power of the air conditioning system.

2. INTRODUCTION TO CONDENSOR

A condenser or evaporator is a heat exchanger, allowing condensation, by means of giving off, or taking in heat respectively.

The construction principle:

Refrigerant and air will be physically divided, 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

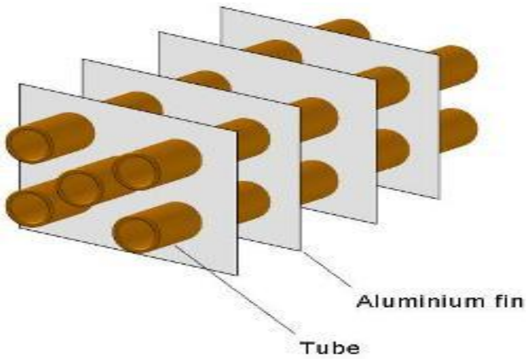
SPECIFICATIONS OF CONDENSOR

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
- refrigerant is **totally**boiled before the evaporator's exit

Those two, depends mainly on the size of the compressor and refrigerant used.

TUBE TYPE CONDENSER



3.Literature Survey:

Balaji N *et al* [1]The majority of the research work focused large chillers. But in this paper discusses the single split air conditioning system using substitute of air cooling using liquid 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'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 26 seconds earlier. It is apparent 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 Stalin*et al* [2] As the energy demand in our day to day life mount 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 tactile 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 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.

J. Steven Brown a*et al* [3] This paper evaluates performance merits of CO2 and R134a automotive air conditioning systems using semi-theoretical cycle models. The R134a system had a current-production configuration, which consisted of a compressor, condenser, expansion device, and evaporator. The CO2 system was additionally equipped with a liquid-heat exchanger. Using these two systems, an effort was made to derive an equitable comparison of performance; the components in both systems were equivalent and variation in thermodynamic and transport properties were accounted for in the simulations. The analysis results R134a having a higher COP than CO2 with the COP inequality being dependent on compressor speed(system capacity) and ambient temperature. For a compressor speed of 1000RPM, the COP of CO2 was lower by 21% at 32.2_C and by 34% at 48.9_C. At higher speeds and ambient temperatures, the COP disparity was even greater. The entropy generation calculations indicated that the large entropy generation in the gas cooler was the primary cause for the lower performance of CO2.

Rich[4](19973) studied the effect of varying the fin spacing on the heat transfer and friction performance of the heat transfer and friction performance of multi-row heat exchanger coils 8 Rich found that over the range from 3 to 14 fins per inch, the air-side heat transfer coefficient was independent of fin pitch

M. Joseph Stalin *et al* [5], As the energy demand in our day to day life increase significantly, there area lot 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 a fantastic job. One such low grade energy is heat energy. So it is imperative that a important and strong 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 gas using air conditioner waste heat. Now a day, Air Conditioner is a banal device which 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 the pump until our desired temperature is acquired. Then the hot water is accumulated in insulated tank for our use. 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.

P.Sathiamurthi *et al* [6], Research has been carried out on the theory, design and construction of heat pipes, especially their use in heat pipe heat exchangers for energy recollection, 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 air should 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.

Sathiamurthi et al [7], discussed in studies on Waste Heat Recovery from an Air
Conditioning Unit that the energy can be recollected and utilized without sacrificing comfort level in 2011.

N.Balaji [8], confabulated that he used intercooler which increases the efficiency of Air
Conditioning system in 2012. Similarly lots of works are going on in waste heat recovery.

Kaushik and Singh [9], confabulated about 40 percent of heat is recovered using Canopus heat exchanger in 1995.

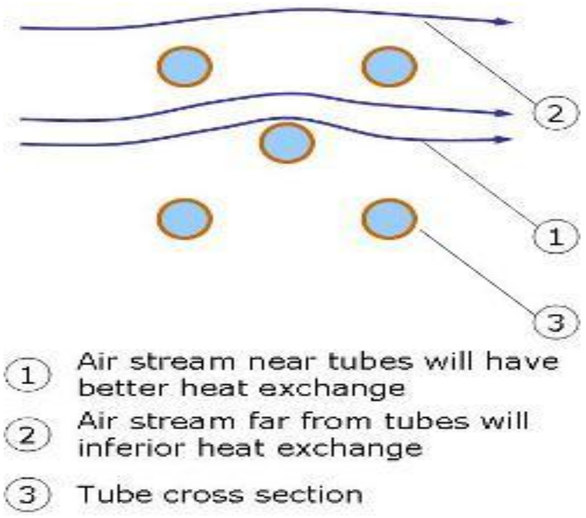
R. Tugrul Ogulata et al [10],The growing cost of energy has required its more effective use. However, many industrial heating processes generate waste energy. Use of the waste-heat recovery systems decreases energy consumption. Drying is often one of the most energy-intensive operations in textile processes and such dryers exhaust large amounts of warm and moist air. The heat-recovery systems utilize the heat produced for the drying process.

4.CONTACT FACTOR:

It is the amount of media that wants to be heated 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



The maximum theoretical contact factor is 100%. We will have contact factors around 80% for commercially produced air conditioner evaporators and air conditioner condensers. The real figures really depend on each manufacturer. The reciprocal of the contact factor, is the **bypass factor**, where it is equal to 1 – contact factor.

Cooling Load Calculations

Cooling load calculations for air conditioning system design are mainly used to determine the flow rate of volume of air system as well as the rate of volume of air system as well as the coil and refrigeration load of the equipment to size then HVAC&R equipment and to select optimal design alternatives.Cooling load usually can be classified into two categories:external and internal

External Cooling Loads.

These loads are formed because of heat gains in the conditioned space from external sources through the building envelope or building shell and the partition walls.
Sources of external loads include the following cooling loads:

1. Heat gain entering from the exterior walls and roofs
2. Solar heat gain transmitted through the fenestrations
3. Conductive heat gain coming through the fenestrations
4. Heat gain entering from the partition walls and interior doors
5. Infiltration of outdoor air into the conditioned space

Internal Cooling Loads.

These loads are formed by the release of sensible and latent heat from the heat sources inside the conditioned space. These sources contribute internal cooling loads:

1. People
2. Electric lights
3. Equipment and appliances

If moisture transfers from the building structures and the furnishings are excluded, only infiltrated air, occupants, appliances, and equipment have both sensible and latent cooling loads. The remaining components have only sensible cooling loads. All sensible heat gains entering the conditioned space represent radiative heat and convective heat except the infiltrated air, radiative heat causes heat storage in the building structures, converts part of the heat gain into cooling load, and makes the cooling load calculation more complicated. Latent heat gains are heat gains from moisture transfer from the occupants, equipment, appliances, or infiltrated air. If the storage effect of the moisture is ignored, all release heat to the space air instantaneously and, therefore, they are instantaneous cooling loads.

External cooling load calculations

Roof&wall:

$$Q = U * A * (CLTD)$$

Solar load through glass:

Conductive:

$$Q_{Glass\ Conductive} = U * A * CLTD_{Glass\ Corrected}$$

Solar Transmission $Q_{Glass\ Solar} = A * SC * SCL$

Partitions ceilings and floors:

$$Q = U A (Ta - Trc)$$

Internal Cooling Loads

People

$$Q_{sensible} = N (Q_S) (CLF)$$

$$Q_{latent} = N (Q_L)$$

Lights

$$Q = 3.41 \times W \times F_{UT} \times F_{SA} \times (CLF)$$

Power Loads

If the motor and the machine are in the room the heat transferred can be calculated as

$$Q = 2545 * (P / Eff) * F_{UM} * F_{LM}$$

Appliances

$$Q_{Sensible} = Q_{in} \times F_u \times F_r \times (CLF)$$

$$Q_{Latent} = Q_{in} \times F_u$$

Infiltration Air

$$Q_{sensible} = 1.08 \times CFM \times (To - Ti)$$

$$Q_{latent} = 4840 \times CFM \times (Wo - Wi)$$

$$Q_{total} = 4.5 \times CFM \times (ho - hi)$$

Heat Gain from Miscellaneous Sources Supply

Fan Heat Load

$$Q = 2545 \times [P / (Eff_1 \times Eff_2)]$$

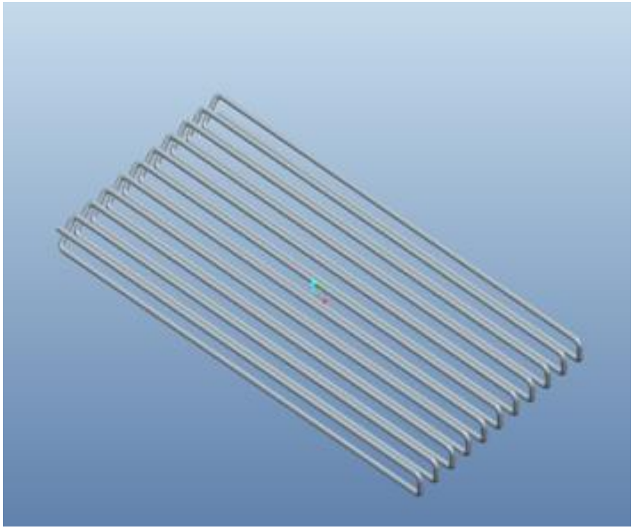
Ventilation Air

$$Q_{sensible} = 1.08 \times CFM \times (T_o - T_c)$$

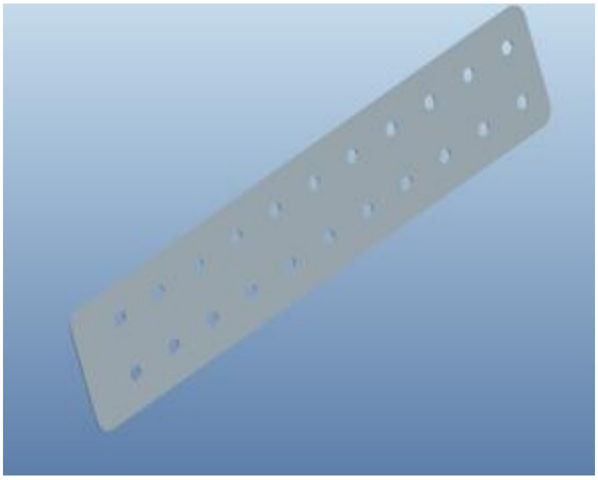
$$Q_{latent} = 4840 \times CFM \times (W_o - W_c)$$

$$Q_{total} = 4.5 \times CFM \times (h_o - h_C)$$

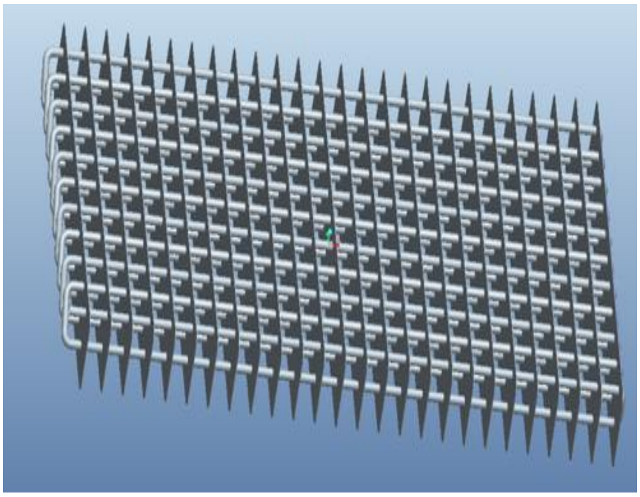
5.MODEL OF CONDENSERTUBE



PLATE



ASSEMBLY OF CONDENSER TUBE AND PLATES



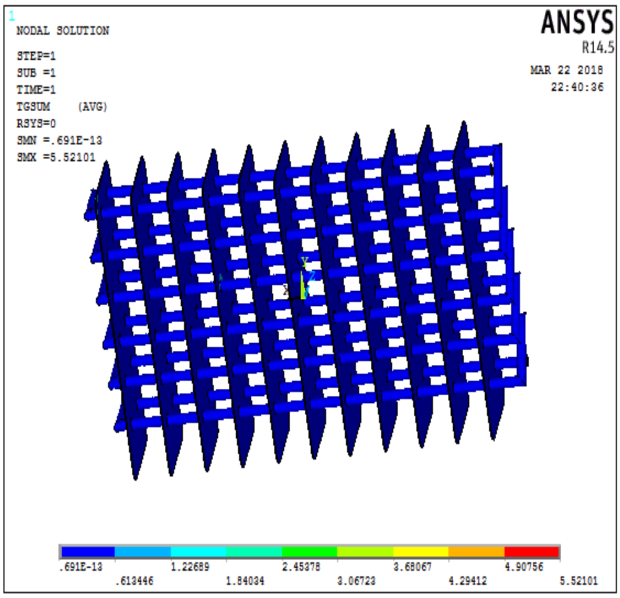
6.THERMAL ANALYSIS OF CONDENSER

ANSYS is general-purpose finite element evalution (FEA) package of software. Finite Element Analysis is a numerical method of evaluate a complicated system into very small sections (of user-designated size) called elements. The package of softwareexecution equations that commands the bearing of these elements and interpret them all; creating complete explanation of system to know how acts as a total system. These solutions then can be showed in tabular, or graphical forms. This kind of evalution is normally used for design and optimization of a system far too complicated to evaluate by hand. Systems that fit into this group are too complicated due to their scale, geometry,or governing equations.

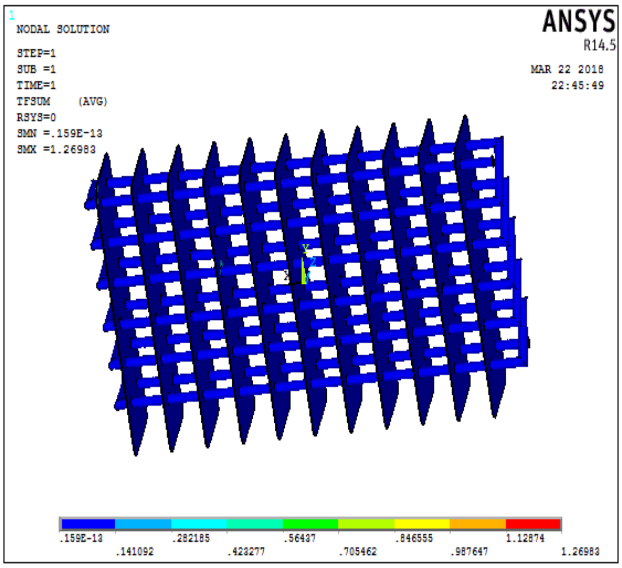
Generic Steps to Solving any Problem in ANSYS :

- Build Geometry
- Define Material Properties
- Generate Mesh
- Apply Loads
- Obtain Solution

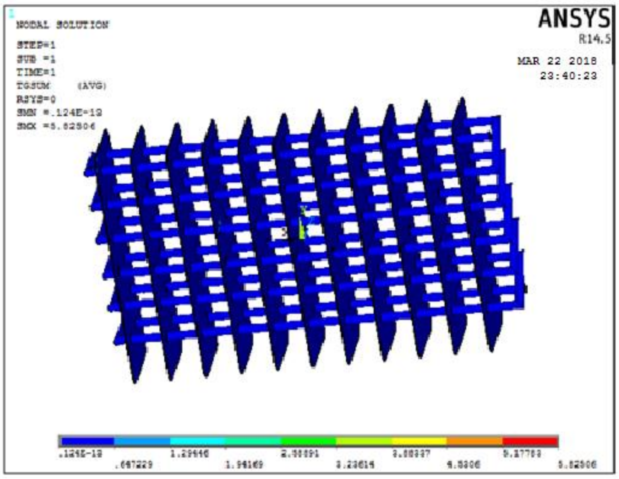
Thermal gradient of AL1100 with working fluid HCFC refrigerant



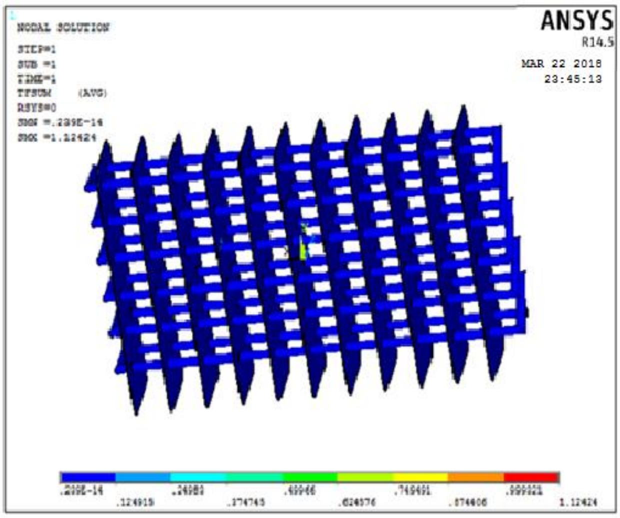
Heat flux of AL1100 with working fluid HCFC refrigerant



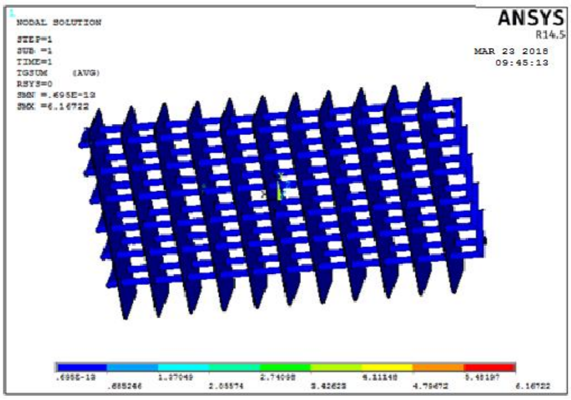
Thermal gradient of Al6063 wih working fluid HCFC refrigerant



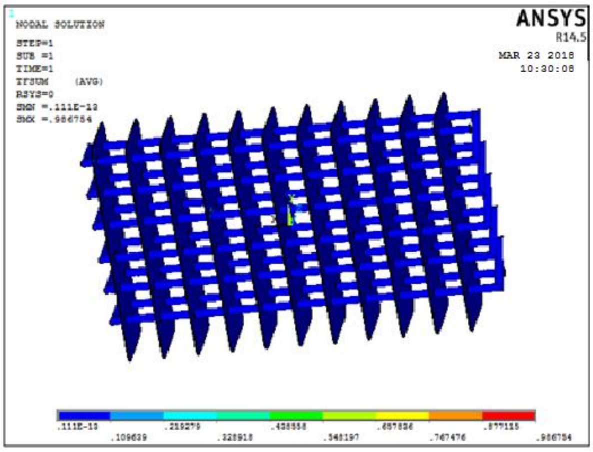
Heat flux of Al6063 with working fluid HCFC refrigerant



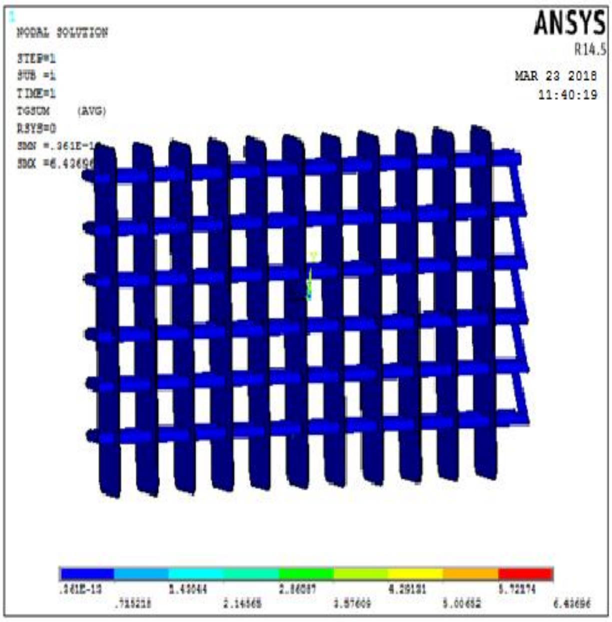
Thermal gradient of Magnesium with working fluid HCFC refrigerant



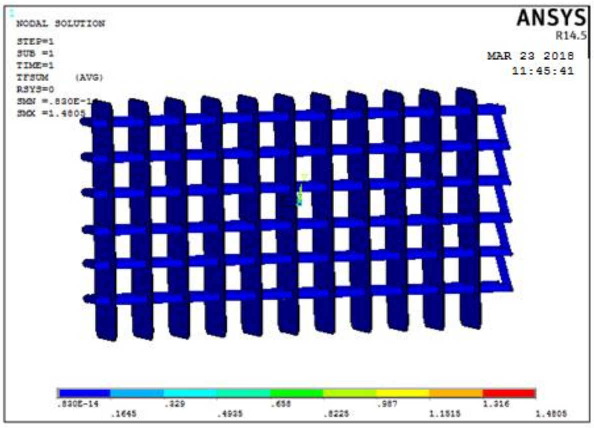
Heat flux of Magnesium with working fluid HCFC refrigerant



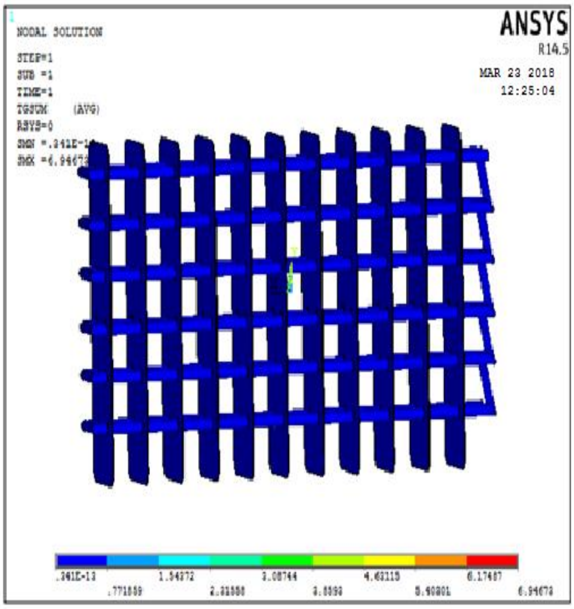
Thermal gradient of AL1100 with working fluid 404R refrigerant



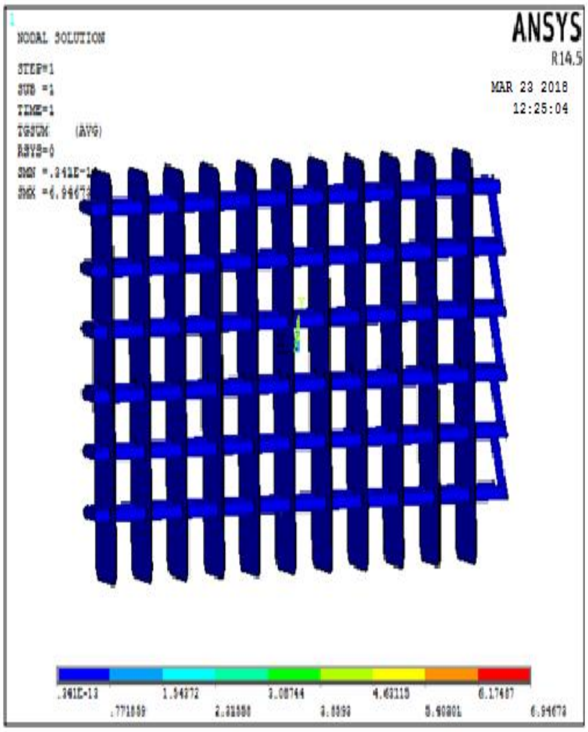
Heat flux of AL1100 with working fluid 404R refrigerant



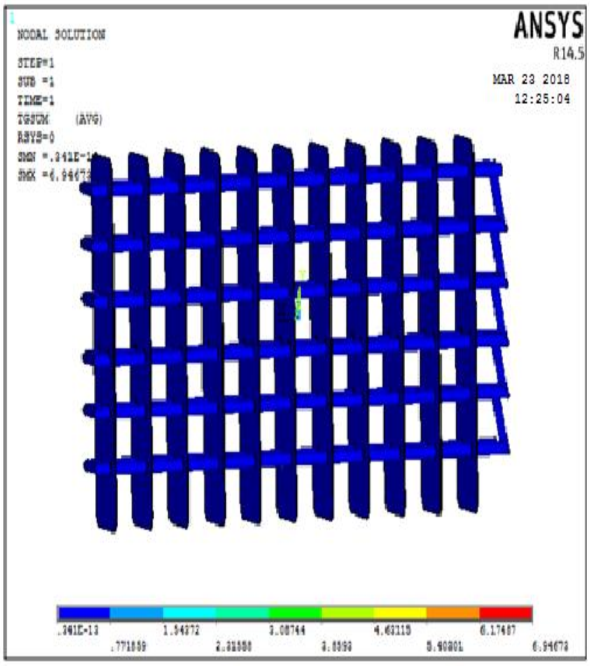
Thermal gradient of Al6063 wih working fluid 404R refrigerant



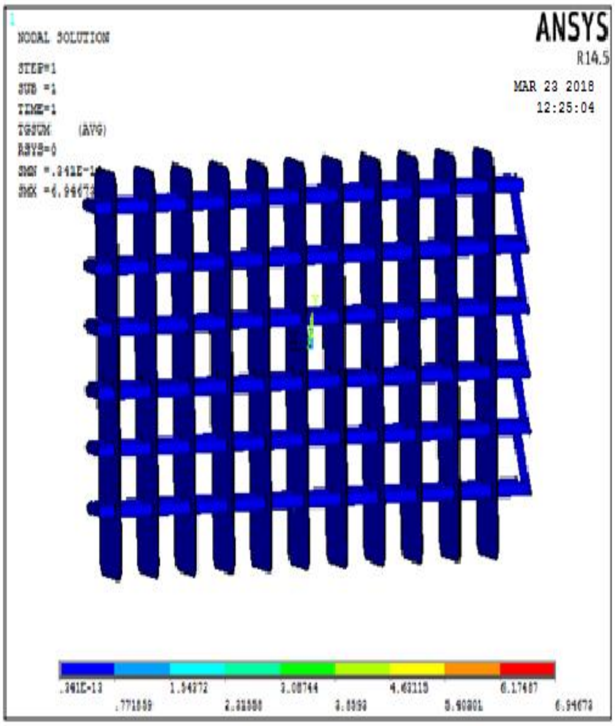
Heat flux of Al6063 with working fluid 404R refrigerant



Thermal gradient of Magnesium with working fluid 404R refrigerant



Heat flux of Magnesium with working fluid 404R refrigerant



7.RESULTS AND DISCUSSION

THERMAL ANALYSIS RESULT TABLE

TABLE 1

RESULTS	REFRIGERANTS					
	HCFC			404R		
	MATERIALS			MATERIALS		
	AL 1100	AL 6063	MG	AL 1100	AL 6063	MG
Nodal Temperature (k)	313	313	313	313	313	313
Thermal Gradient (k/mm)	5.52101	5.82506	6.16722	6.43696	6.07077	6.94673
Heat flux (W/mm^2)	1.26983	1.12424	0.986754	1.4805	1.28162	1.11148

In the above table, the nodal temperature, thermal gradient and thermal flux values are presented from thermal analysis results. From the results, thermal flux is more when Aluminum alloy 1100 is used for fin and refrigerant used is 404. That is the heat transfer rate is more. Thermal gradient is also more that is the change in temperature over a distance is more.

THEORETICAL THERMAL FLUX RESULTS

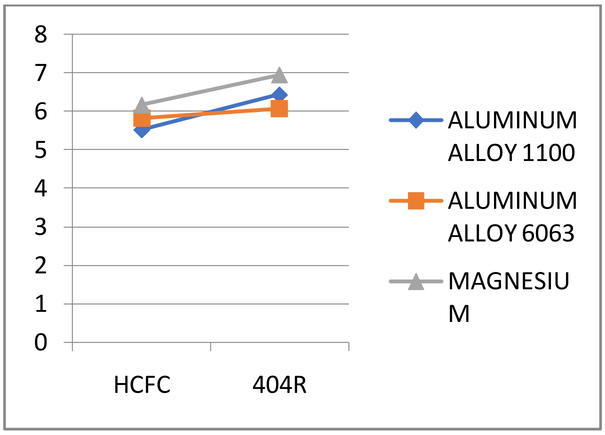
TABLE 2

	Al ALLOY 1100	Al ALLOY 6063	MAGNESIUM
HCFC	**2.64**	**2.44**	**2.21**
R404	**2.69**	**2.488**	**2.24**

In the above table, thermal flux values are presented from theoretical calculations. From the results, thermal flux is more when Aluminum alloy 1100 is used for fin and refrigerant used is 404. That is the heat transfer rate is more.

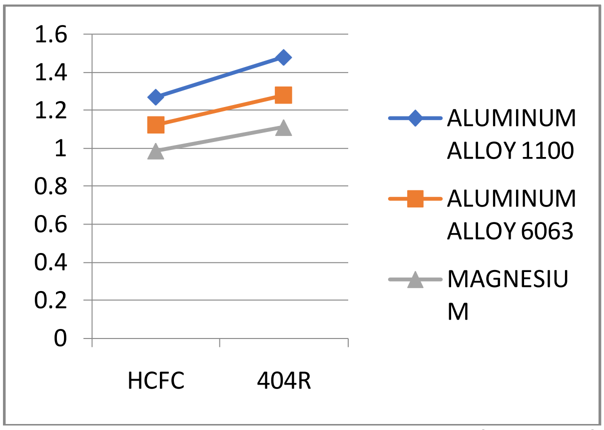
8.COMPARISON GRAPHS

THERMAL GRADIENT COMPARISON GRAPH



The above graph represents the comparison of thermal gradient values for all the 3 materials and two refrigerants. It shows that refrigerant 404R and aluminum alloy 1100 has more thermal gradient value.

THERMAL FLUX COMPARISON GRAPH



The above graph represents the comparison of thermal flux values for all the 3 materials and two refrigerants. It shows that refrigerant 404R and aluminum alloy 1100 has more thermal flux value.

9.CONCLUSION

In this paper, an ac condenser is designed and optimized for better material, refrigerant and thickness to enhancing the heat transfer rate. Present fin material is Aluminum alloy 204 and cooling fluid is HCFC. Modeling is done in Pro/Engineer

For best result condenser is optimized, thermal analysis done on condenser. Analysis done through fin materials Aluminum Alloy 1100, Aluminum Alloy 6063 and Magnesium alloy. And also by changing the cooling fluid HCFC and R404.

By observing the thermal analysis results, by using fin material Aluminum alloy 1100, thermal flux is more than by using other two materials. So by using Aluminum alloy 1100, the heat transfer rate increases. And also by taking refrigerant R404 is better.

Thermal flux is also calculated theoretically, by observing the results, using fin material Aluminum alloy 1100 and refrigerant R404 has more heat transfer rate.

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