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IMPROVING THE HEAT TRANSFER RATE OF AIR CONDITIONER CONDENSER BY OPTIMIZING MATERIAL USING CFD

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Abstract: An air conditioner's condenser is responsible for removing excess heat from the refrigerant and transferring it to the outside. The main part of a condenser is usually the coil that the refrigerant runs through. This research uses computational fluid dynamics (CFD) and thermal analysis to find the heat transfer by convection in an air conditioner as a function of changing the refrigerants. The evaluation for a vapour compression cycle air conditioner's air-cooled tube condenser is now available. Aluminium alloys 6061 and 7075, as well as copper, are being studied as potential tube materials. R22, R134, and R407C will be the refrigerants that are altered. Changing the refrigerants causes the CFD model to change, which in turn changes the heat transfer rates and distributions. In order to determine which material is superior, heat transfer study is performed on the condenser.We use CREO for 3D modelling and ANSYS for analysis.

Keywords: Air conditioner condenser, CFD, CREO and R407c

1. INTRODUCTION

To remove excess heat and humidity from a room, you may install an air conditioner. A basic refrigeration cycle is used to accomplish the cooling. A comprehensive HVAC system is called a "HVAC" in the building industry. Whether in a building or a car, it's job is to keep the occupants cool or warm. The HVAC system of a car is designed to make the driver and passengers as comfortable as possible. Comfort is one of the most crucial factors that has to be met. As to the American Society of Heating, Refrigeration and Air Conditioning Engineers (ASHRAE), a person is considered to be in a state of comfort when they are happy with their surrounding environment.In order to keep the interior temperature within acceptable limits while maximising energy efficiency, an AC control system primarily adjusts the AC system's capacity in response to changes in the weather and the design specifications.

levels of usage during the whole trip. The condenser is a crucial component of any air conditioning system. The front-mounted condenser acts as a heat exchanger, taking in hot, high-pressure refrigerant from the compressor. When travelling at high speeds on the highway or with an electric cooling fan, the air conditioning system's refrigerant is cooled by the wind via the condenser. The process of subcooling condensate and desuperheating high-temperature vapour is what makes this kind of condenser work. An essential component, the condenser's primary job is to cool the heated vapour refrigerant that is expelled by the compressor. The evaporator's heat absorption and the compressor motor's compression heat are both included in the hot vapour refrigerant. *Corresponding author: Parikshit A. Ladke. Transmitting heat from the heated vapour refrigerant to the condenser tube walls and subsequently to the cooling medium is how a condenser removes heat from a system. Air and water are the most common cooling media. The minichannel parallel flow condenser was developed and refined by J.B. Copetti et al.

for use in vehicle air conditioning systems, using the refrigerant R-134a. The geometric parameters, such as the number of channels, the height and breadth of the tube, and the layout of the refrigerant side passes, were varied in order to achieve optimisation. The wire-on-tube condenser with varying wire spacing was experimentally examined by Viveksahuet. al. The optimisation was achieved by adjusting operational parameters such as condenser temperature and pressure.

2. LITERATURE REVIEW

The authors Aytune, Erek, and colleagues [1] found that the surface area for heat transfer increases with increasing fin height, leading to higher values for both heat transfer and pressure drop.Reducing the tube's thickness improves heat transmission while lowering its pressure drop. Due to the fact that in this scenario, water and flue gas have a lower heat resistance. A similar assessment of R600a (isobutene), R290 (propane), R134a, R22, R410A, and R32 in an optimised finned-tube evaporator was given by David Yashar et al. [2]. Additionally, it examines how the evaporator's impacts affect the COP of the system. The quantification of the heat transfer increase related with interrupted fins was done by Jader R. Barbosa et al. [3]. With interrupted fins, we can reduce the fin surface area by 33% and the air side pressure drop by 15% compared to the baseline configuration, while still achieving a heat transfer rate that is comparable to the baseline (continuous fins). The temperature difference between castor oil and water moving at the same speed is quite apparent, according to Apu Roy et al. [4]. The reason for this is because castor oil has superior thermal characteristics compared to water. An improved
5. Castor oil is a good heat transmission fluid, as opposed to the more conventional water. Case-I displays the results of the real readings calculated by Devendra A. Patel et al. [5], whereas case-II displays the results of the simulation calculations performed on the assumption that the entrance temperatures of the oil and cooling water would remain constant. ii) Case-II has a better overall heat transfer coefficient and efficacy than case-I due to the lower oil outlet temperature in case-H, which results in decreased values of the heat transfer rate.

Calculations and results for simulated readings are shown in sections III and IV. In every instance, the temperature of the cooling water input is lowered by 2 degrees. Iv) Q-max values rise with increasing variation in the temperature differential between the oil and water inlets. Now you know. Both case-in and case-VI have better heat transfer rates, total heat transfer coefficients, and efficacy than case-II.

3. MATERIALS AND METHODS

Aluminum alloy

Aluminum alloys have high electrical conductivity and strong corrosion resistance characteristics. These alloys are good low-temperature alloys. They gain strength when exposed to subzero temperatures and lose strength when exposed to high temperatures

Copper

Copper is a good conductor of heat. This means that if you heat one end of a piece of copper, the other end will quickly reach the same temperature. Most metals are pretty good conductors; however, apart from silver, copper is the best.

Table: 1 Thermal properties

Materials	Thermal conductivity (w/m k)	Specific heat (j/kg-k)	Density (kg/m^3)
Aluminum alloy 7075	163	880	2705
Aluminum alloy 6061	158	910	2710
Copper	385	385	8960

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Refrigerants

The HFC refrigerant family includes R134a, which is another name for tetra fluoroethane (CF3CH2F). Ever since the ozone layer damage caused by CFCs and HCFCs refrigerants was discovered, the HFC family of refrigerants has taken control.

a substitute. It has recently supplanted R-12 CFC as the preferred refrigerant for rotary screw, reciprocating, centrifugal, and scroll compressors. Due to its lack of toxicity, combustibility, and corrosion, it is perfectly safe for everyday handling.

Properties

Properties	R-134a
Boiling Point	-14.9°F or -26.1°C
Auto-Ignition Temperature	1418°F or 770°C
Ozone Depletion Level	0
Solubility In Water	0.11% by weight at 77°F or 25°C
Critical Temperature	252°F or 122°C
Cylinder Color Code	Light Blue
Global Warming Potential (GWP)	1200

R-407C is a mixture of hydrofluorocarbons used as a refrigerant. It is a zeotropic blend of difluoromethane (R-32), pentafluoroethane (R-125), and 1,1,1,2-tetrafluoroethane (R-134a). Difluoromethane serves to provide the heat capacity, pentafluoroethane decreases flammability, tetrafluoroethane reduces pressure.[1] R-407C cylinders are colored burnt orange.

Properties	R-407C
Molecular Weight	86.2
Boiling point (°C)	−43.8
Saturated liquid density	1138
Saturated vapour density	43.8
Critical temperature (°C)	86.4
Critical pressure, bar	46.3
Liquid heat capacity	1.533

METHODOLOGY

- Study the literature review.

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- Create the 3D model of Air conditioner condenser with help of CATIA parametric software.
- Selection of fluids, R134A, R22 and R 407C.
- Perform CFD and thermal analysis on the evaporator assembly for thermal loads.

Fig :flow chart

PROBLEM DESCRIPTION:

The objective of this project is to make a 3D model of the condenser and study the CFD and thermal behaviorof the condenser by performing the finite element analysis.3D modeling software CATIA was used for designing and analysis software (ANSYS) was used for CFD and thermal analysis.

4. MODELING AND

ANALYSISCATIA

Parametric Software

The process of creating a product or other item with the use of computer programmes is known as computer-aided design (CAD). A manufacturing plant's operations may be better planned, managed, and controlled with the use of computer software and technology using Computer Aided Manufacturing (CAM). Software for solving engineering issues and analysing CAD-created products is known as computer-aided engineering (CAE)."Computer Aided Three-dimensional Interactive Application" goes by the abbreviation CATIA. It ranks among

the most popular 3D programme utilised by companies across a wide variety of sectors, including aerospace, automotive, and consumer goods. Dassault Systems' CATIA is a 3D software package that includes CAD, CAM, and CAE, and it is compatible with several platforms.

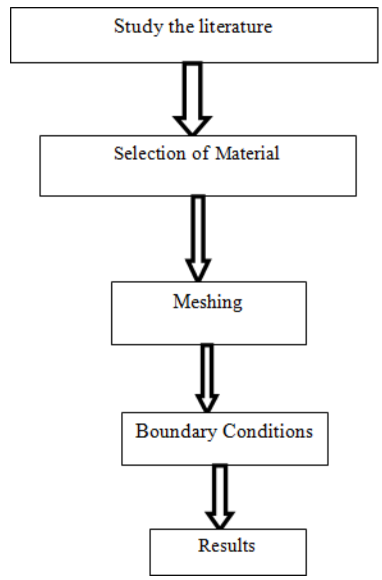
ANSYS

The governing equations in ANSYS Forte follow mainly the Continuity equation, Momentum equation (Navier Stokes equation) and Energy equation to solve computational fluid dynamics problem.

The conservation equation for species is given by:

$$\frac{\partial \rho}{\partial t} k + \nabla \cdot \rho k u = \nabla \cdot \rho D T \nabla \rho k \rho + \rho k c + \rho k s k = 1, \cdots, K \quad (1)$$

Where: ρ is the density, subscript k is the species index, K is the total number of species, $u$and is the flow velocity vector.



Application of Fick's Law ofdiffusion results in a mixture-averaged turbulent diffusion coefficient DT. $\rho k c$andρk s are source terms due to chemical reactions and spray evaporation, respectively. The summation of Equation 1 over all species gives the continuity equation for the total fluid

$$\frac{\partial \rho}{\partial t} + \nabla \cdot (\rho \cdot u) = \rho \quad (2)$$

Research into steady-state thermal assessments calculates the effects of constant heat loads on a structure or component. Before completing a brief warm inquiry, clients often act out a constant state examination to aid set up starting conditions. The last step of a temporary warm study, carried out after all temporary impacts have subsided, might also be a constant state assessment. ANSYS may be used to determine the temperatures, warm slopes, heat streams, and heat transitions in an object due to static heat loads.

Computational Fluid Dynamics (CFD) is a subfield of liquid mechanics that deals with and analyses problems involving fluid streams via the use of numerical methods and computations. The counts needed to recreate the interaction of limit-state surfaces with fluids and gases are performed on personal computers. Better arrangements can be achieved with the help of fast supercomputers. Programming that increases the precision and speed of complicated reenactment scenarios is one example of how ongoing research produces useful outcomes.

transonic or tempestuous streams. Starting test approval of such programming is performed utilizing an air stream with the last approval coming in full- scale testing, for example flight tests.

3D MODELING OF CONDENSER

The Model Is Designed From Based On Journal Of Plate-Fin-And-Tube Condenser Performance And Design For Refrigerant R-410a Air-Conditioner.

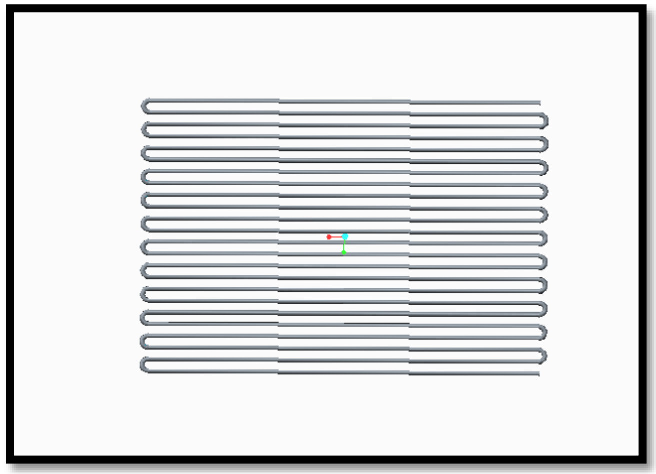


Fig - 3D Model

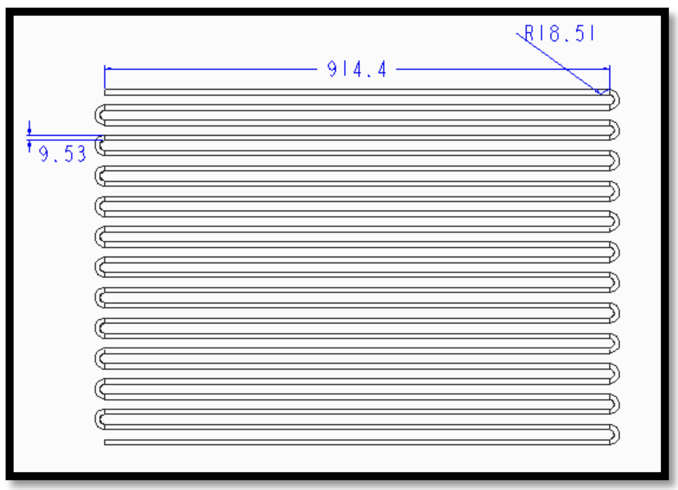


Fig - 3D Model

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5. CFD ANALYSIS OF AIR CONDITIONER CONDENSER

Fluid-R134a

Imported model

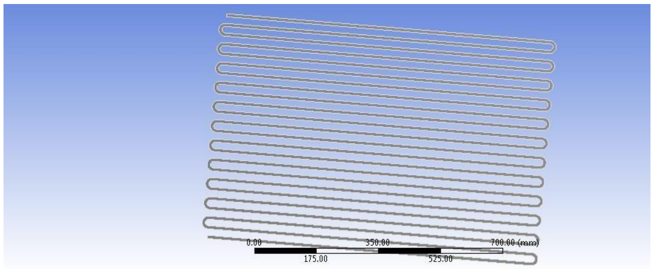


Fig: imported model from 3D modeling software

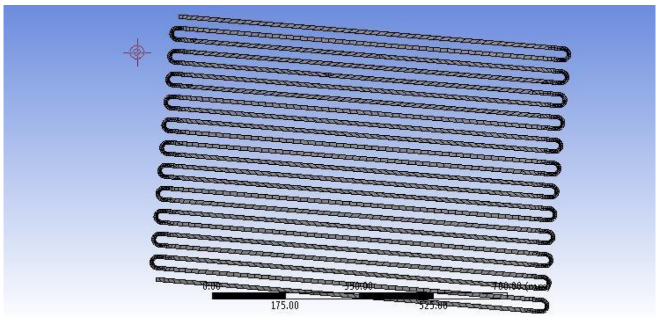


Fig – Meshed Model

The model is designed with the help of CATIA and then import on ANSYS for Meshing and analysis. The analysis by CFD is used in order to calculating pressure profile and temperature distribution. For meshing, the fluid ring is divided into two connected volumes. Then all thickness edges are meshed with 360 intervals. A tetrahedral structure mesh is used. So the total number of nodes and elements is 6576 and 3344.

Static Pressure Drop

According to above the plot the maximum pressure at inlet of the tube and minimum pressure at outlet of the tube

Temperature

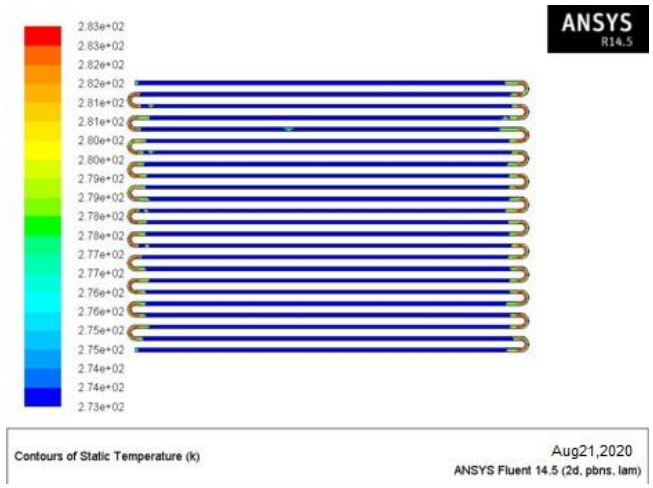
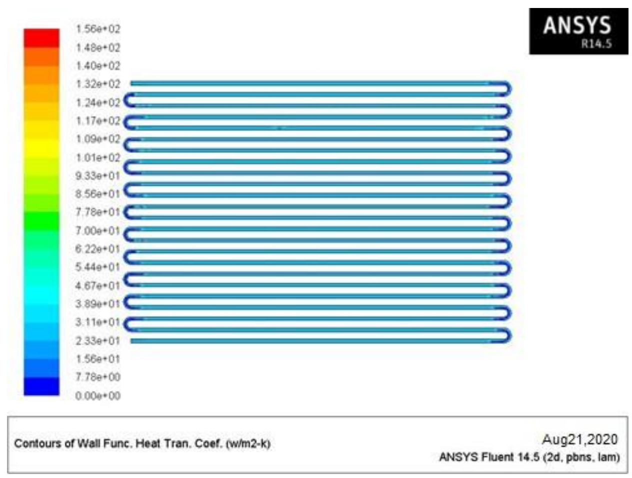


Fig: Static Temperature

Wall Function Heat Transfer Coefficient



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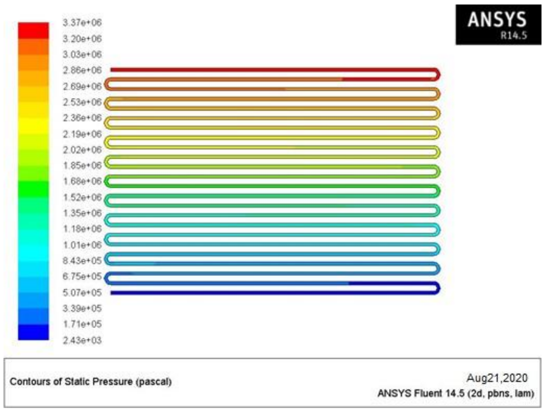

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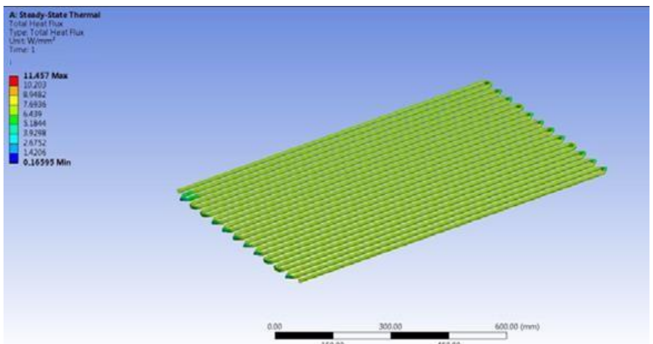
THERMAL ANALYSIS OF AIR CONDITIONER CONDENSER

MATERIAL-COPPER

HEAT FLUX



According to the contour plot, the maximum heat flux at inside the tubes because the fluid passing inside of the tube. So we are applying the temperature inside of the tube and applying the convection except inside the tubes. Then the maximum heat flux at inside the tubes andminimum heat flux at heat exchanger casing and outside of the tubes.

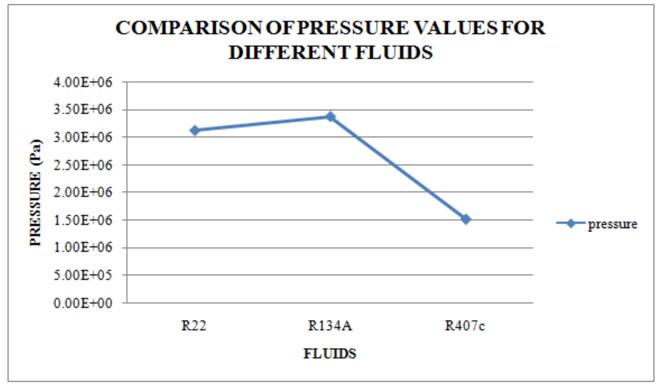
RESULT TABLES

Table: 1 CFD RESULT TABLES

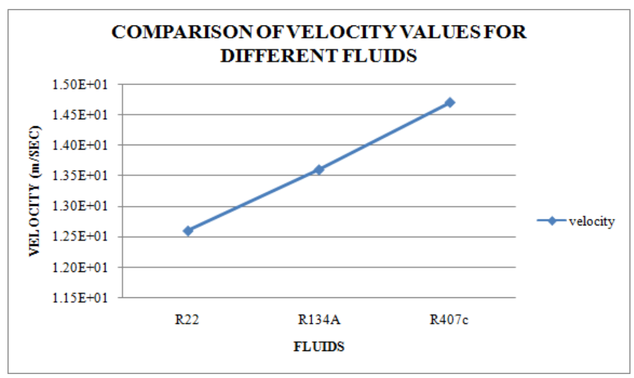
Fluids	Pressure (Pa)	Temperature (K)	Velocity (m/Sec)	Wall Function Heat Transfer Coefficient (W/m^2-K)	Mass Flow Rate (Kg/Sec)	Total Heat Transfer Rate (W)
R22	3.12e^{+06}	2.80e^{+02}	1.26 e^{+01}	1.08e^{+02}	-0.0278429	855.549
R134A	3.37e^{+06}	2.83e^{+02}	1.36 e^{+01}	1.56e^{+02}	0.013374329	-181.78711
R407C	1.52e^{+06}	2.83e^{+02}	1.47 e^{+01}	1.47e^{+02}	-0.01423645	-48.704102

GRAPHS

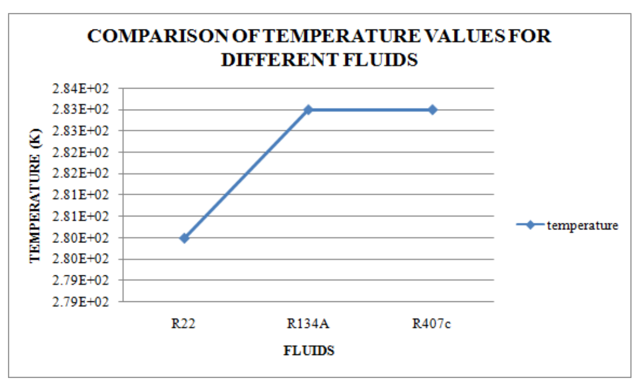
Graph 1: Comparison of Pressure Values for Different Fluids



Graph 2: Comparison of Velocity Values for Different Fluids



Graph3: Comparison of Temperature Values for Different Fluids



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Graph 4: Comparison of Heat Transfer Coefficient Values for Different Fluids

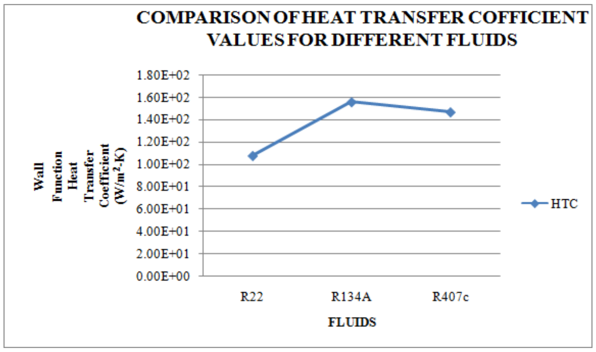
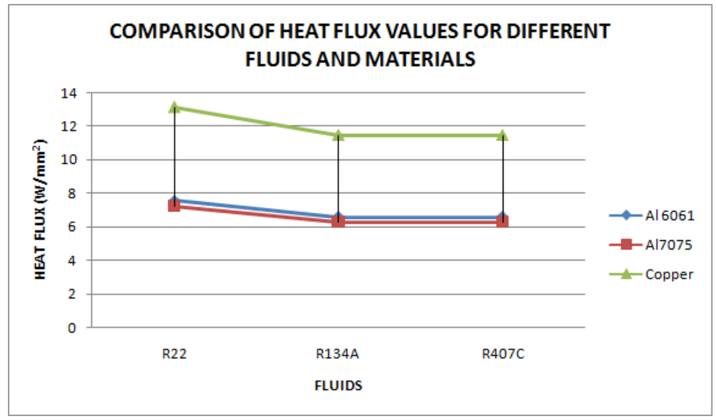


Table: 2 Thermal analysis results

Materials	Fluids	Convection (W/m^2 K)	Temperature (°C)	Heat flux (W/mm^2)
ALUMINIUM 6061	R22	108	303.15	7.5558
	R134a	156	303.15	6.5842
	R407c	147	303.15	6.5831
ALUMINIUM 7075	R22	108	303.15	7.2285
	R134a	156	303.15	6.2986
	R407c	147	303.15	6.2976
COPPER	R22	108	303.15	13.137
	R134a	156	303.15	11.457
	R407c	147	303.15	11.454

Graph 5: Comparison of Heat Flux Values for Different Fluids and Materials



CONCLUSION

This research uses computational fluid dynamics (CFD) and thermal analysis to find the heat transfer via convection in air conditioning (AC) as a function of changing the refrigerants. The evaluation for a vapour compression cycle air conditioner's air-cooled tube condenser is now available.
Aluminium alloys 6061 and 7075, as well as copper, are being studied as potential tube materials. R22, R134, and R407C will be the refrigerants that are altered. Changing the refrigerants causes the CFD model to change, which in turn changes the heat transfer rates and distributions. In order to determine which material is superior, heat transfer study is performed on the condenser.

According to the findings of the computational fluid dynamics (CFD) investigation, compared to other fluids, R134A has a higher heat transfer coefficient and R22 has a higher heat transfer rate. According to the findings of the thermal investigation, the heat flow is higher when R22 and copper are employed. (that instance, using the fluid R134A with the material Copper results in a higher heat transfer rate).

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