

DESIGN AND ANALYSIS OF A CONDENSER IN A REFRIGERATOR USING DIFFERANT REFRIGERANTS

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ABSTRACT

A **condenser** is designed to transfer heat from a working fluid (e.g. water in a steam power plant) to a secondary fluid or the surrounding air. The **condenser** relies on the efficient heat transfer that occurs during phase changes, in this case during the condensation of a vapor into a liquid. The materials considered for tubes are Copper and Aluminium alloys 1060 and 1100. The refrigerants varying will be R 12, R22 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. In this project thermal analysis to determine the temperature distribution and heat flux at different materials of condenser (copper and aluminium alloys), CFD analysis to determine the pressure drop, velocity, heat transfer coefficient, mass flow rate and heat transfer rate at different refrigerants of the condenser. In this thesis the condenser model designing in CREO and analysis in ANSYS software.

INTRODUCTION

The Refrigeration Cycle The refrigerator in your kitchen uses a cycle that is similar to the one described in the previous section. But in your refrigerator, the cycle is continuous. This is what happens to keep the refrigerator cool: Butane Lighters If you go to the local store and buy a disposable butane lighter with a clear case (so that you can see the liquid butane inside), what you are seeing is liquid butane stored in a high-pressure container. Butane boils at 31

degrees F at normal atmospheric pressure (14.7 PSI).

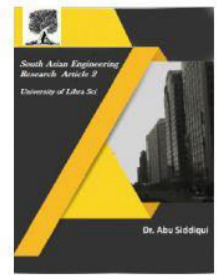
Freon® breaks down ozone into oxygen gas. The reaction is shown below. As of the 1990s, all new refrigerators and air conditioners use refrigerants that are less harmful to the ozone layer.



Use of highly purified liquified propane gas as a refrigerant is gaining favor, especially in systems originally designed for Freon®.



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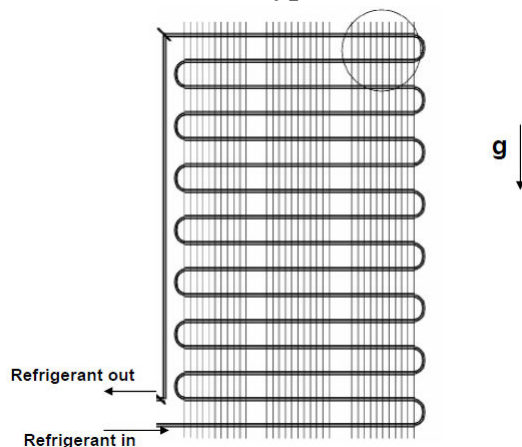


Yes, the same liquid used in barbeque grills. As such, it is designated as R-290 and is marketed under the trade name Duracool®. Although propane is flammable, in home and automotive systems it is present in quantities small enough to not pose an undue fire hazard if a system should develop a leak. Moreover, propane is nontoxic.

1. Air-cooled condensers:

As the name implies, in air-cooled condensers air is the external fluid, i.e., the refrigerant rejects heat to air flowing over the condenser. Air-cooled condensers can be further classified into natural convection type or forced convection type.

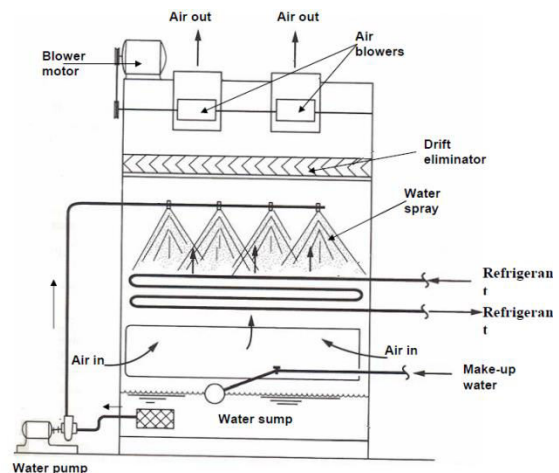
Natural convection type:



In natural convection type, heat transfer from the condenser is by buoyancy induced natural convection and radiation. Since the flow rate of air is small and the radiation heat transfer is also not very high, the combined heat transfer coefficient in these condensers is small. As a result a relatively large condensing surface is required to reject a given amount of heat. Hence these condensers are used for small capacity refrigeration systems like household refrigerators and freezers. The natural

convection type condensers are either plate surface type or finned tube type. In plate surface type condensers used in small refrigerators and freezers, the refrigerant carrying tubes are attached to the outer walls of the refrigerator. The whole body of the refrigerator (except the door) acts like a fin. Insulation is provided between the outer cover that acts like fin and the inner plastic cover of the refrigerator. It is for this reason that outer body of the refrigerator is always warm. Since the surface is warm, the problem of moisture condensation on the walls of the refrigerator does not arise in these systems. These condensers are sometimes called as flat back condensers.

1. Evaporative condensers:



In evaporative condensers, both air and water are used to extract heat from the condensing refrigerant. Figure above shows the schematic of an evaporative condenser. Evaporative condensers combine the features of a cooling tower and water-cooled condenser in a single unit. In these condensers, the water is sprayed from top part on a bank of tubes

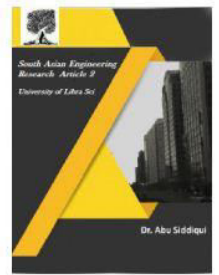


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carrying the refrigerant and air is induced upwards. There is a thin water film around the condenser tubes from which evaporative cooling takes place. The heat transfer coefficient for evaporative cooling is very large. Hence, the refrigeration system can be operated at low condensing temperatures (about 11 to 13 K above the wet bulb temperature of air). The water spray countercurrent to the airflow acts as cooling tower. The role of air is primarily to increase the rate of evaporation of water. The required air flow rates are in the range of 350 to 500 m³/h per TR of refrigeration capacity.

Function of condenser

The main function of condenser is to convert gaseous form of exhaust steam into liquid form at a pressure of below atmosphere. Cooling medium is used water to convert steam into water.

Condenser vacuum and air leakage

The pressure inside the condenser is less than the atmospheric as condensation of steam reduces its volume. The pressure below the atmospheric is called vacuum. In order to obtain the maximum work from unit mass of steam, the pressure should be as low as possible. Because of low pressure inside the condenser, the air infiltrates into the system so the condenser is always filled with a mixture of water, steam and air.

Literature review

Chandrashekhar M. Bagade et al (2012) Day by day there is increasing demand of refrigerating effect which increases the load on compressor. But sub cooling and superheating are the process used for getting maximum refrigerating effect, ultimately

improve COP of the refrigerating system. Condenser plays an important role in any refrigeration system .it is use to remove heat from refrigerant vapour coming from compressor p-h and Ts diagrams clearly shows, the effect of sub cooling after condensate formation on COP. Now a day we are interested in improving COP of refrigeration system, without affecting compressor work. Sub cooling is one of the factors that can improve the COP of refrigeration system. Sub cooling is done in the condenser, thus condenser design is the key factor to improve the COP of domestic refrigerator

PROBLEM DESCRIPTION

The materials considered for tubes are Copper and Aluminium alloys 1060 and 1100. The refrigerants varying will be R 12, R22 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.

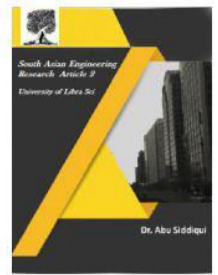
In this project thermal analysis to determine the temperature distribution and heat flux at different materials of condenser (copper and aluminium alloys), CFD analysis to determine the pressure drop, velocity, heat transfer coefficient, mass flow rate and heat transfer rate at different refrigerants of the condenser.

In this thesis the condenser model designing in CATIA and analysis in ANSYS software.

INTRODUCTION TO CAD

CAD (Computer Aided Design) is the use of computer software to design and document a product's design process.

Engineering drawing entails the use of graphical symbols such as points, lines,



curves, planes and shapes. Essentially, it gives detailed description about any component in a graphical form.

INTRODUCTION TO CREO

PTC CREO, formerly known as Pro/ENGINEER, is 3D modeling software used in mechanical engineering, design, manufacturing, and in CAD drafting service firms. It was one of the first 3D CAD modeling applications that used a rule-based parametric system. Using parameters, dimensions and features to capture the behavior of the product, it can optimize the development product as well as the design itself.

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

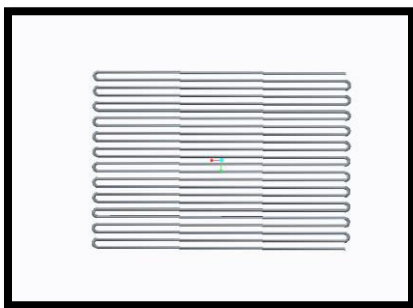


Fig - 3D Model

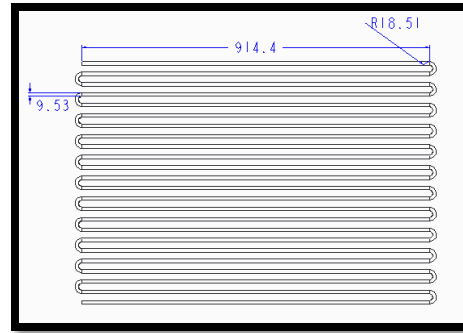


Fig – 2D Drafting

INTRODUCTION TO FEA

Finite element analysis is a method of solving, usually approximately, certain problems in engineering and science. It is used mainly for problems for which no exact solution, expressible in some mathematical form, is available. As such, it is a numerical rather than an analytical method. Methods of this type are needed because analytical methods cannot cope with the real, complicated problems that are met with in engineering. For example, engineering strength of materials or the mathematical theory of elasticity can be used to calculate analytically the stresses and strains in a bent beam, but neither will be very successful in finding out what is happening in part of a car suspension system during cornering.

INTRODUCTION TO ANSYS

Structural Analysis

ANSYS Autodyn is computer simulation tool for simulating the response of materials to short duration severe loadings from impact, high pressure or explosions.

ANSYS Mechanical

ANSYS Mechanical is a finite element analysis tool for structural analysis, including linear, nonlinear and dynamic studies. This computer simulation product provides finite elements to model behavior, and supports material models and equation solvers for a wide range of mechanical design problems. ANSYS Mechanical also includes thermal analysis and coupled-physics capabilities involving acoustics, piezoelectric, thermal-structural and thermo-electric analysis.

CFD ANALYSIS FOR CONDENSER

Save Creo Model as .iges format

→Ansys → Workbench→ Select analysis system → Fluid Flow (Fluent) → double click

→→Select geometry → right click → import geometry → select browse →open part → ok

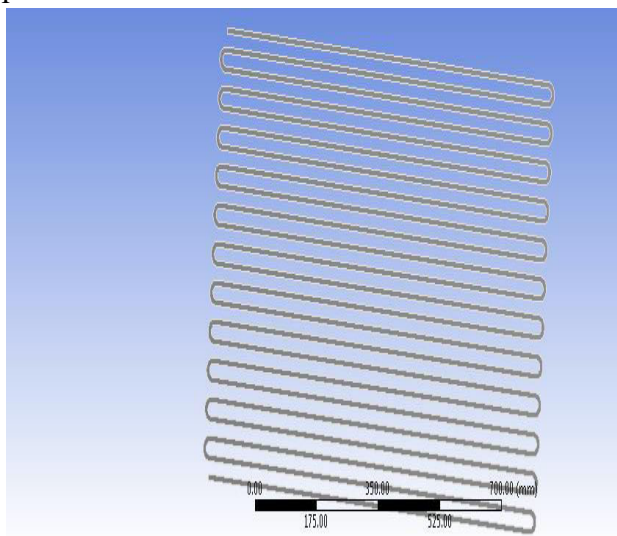


Fig - Imported model from Creo 2.0

→→ Select mesh on work bench → right click →edit

Select mesh on left side part tree → right click → generate mesh →

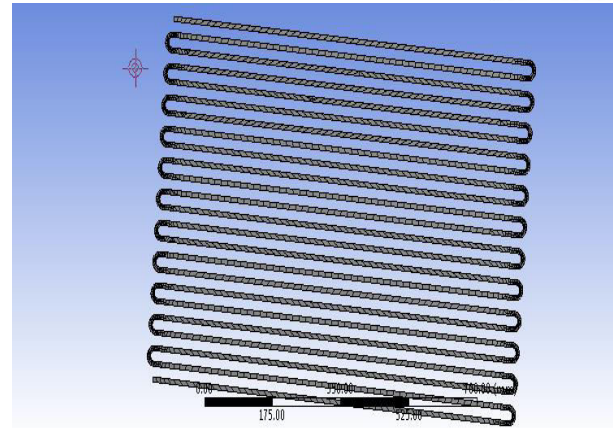


Fig – Meshed Model

SPECIFYING BOUNDARIES FOR INLET AND OUTLET

Inlet

Select edge → right click → create named section → enter name → inlet

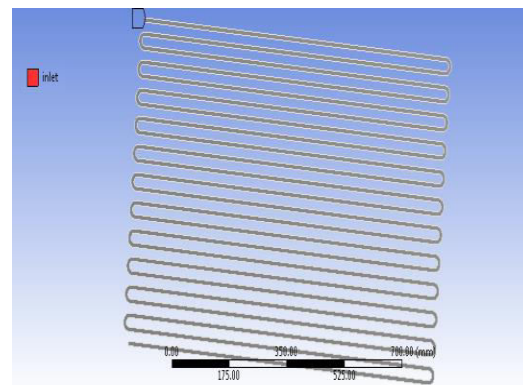


Fig – Fluid inlet

Outlet

Select edge → right click → create named section → enter name → outlet

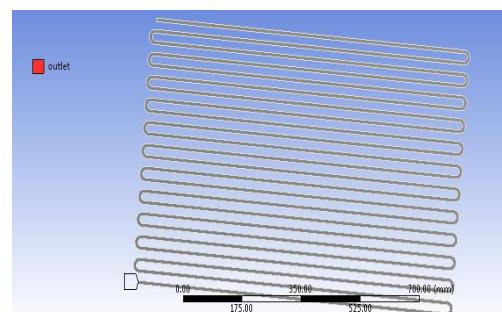


Fig – Fluid outlet

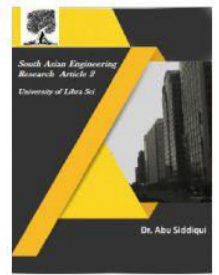


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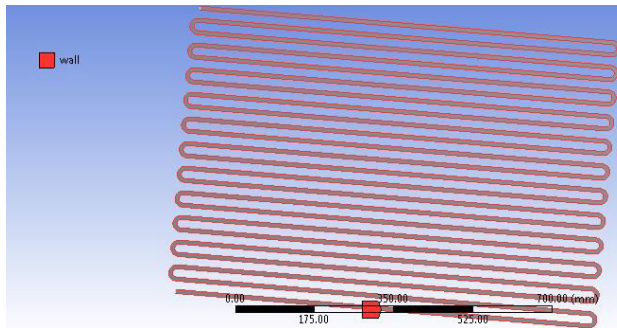
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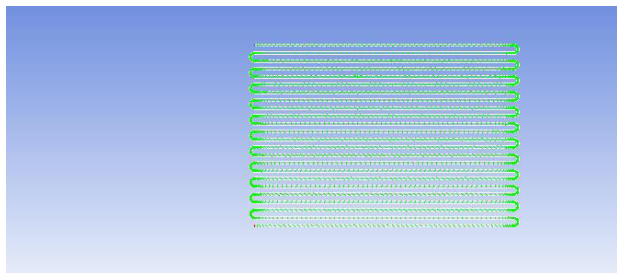
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Wall



File export → fluent → input file (mesh) → save required name → save.
 →→ Ansys → fluid dynamics → fluent → select working directory → ok
 →→ file → read → mesh → select file → ok.



General → Pressure based
 Model → energy equation → on.
 Viscous → edit → k-epsilon

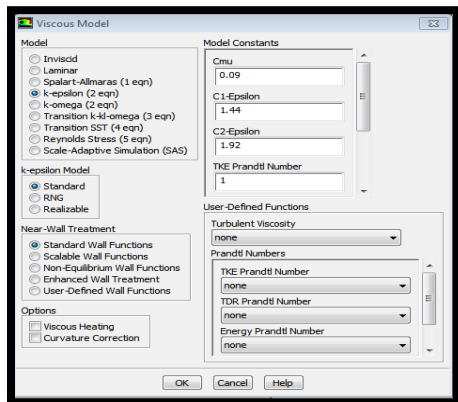


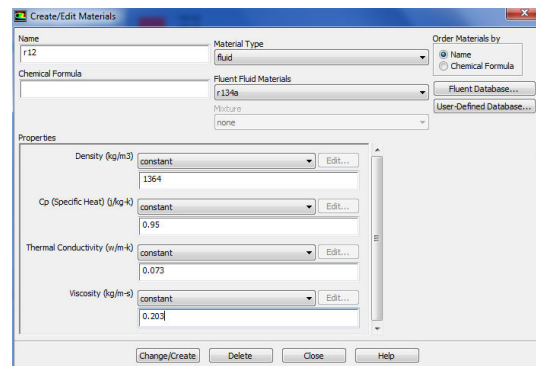
Fig – Viscous Model

Materials → new → create or edit
 → specify fluid material or specify properties
 → Ok

FLUID - R12

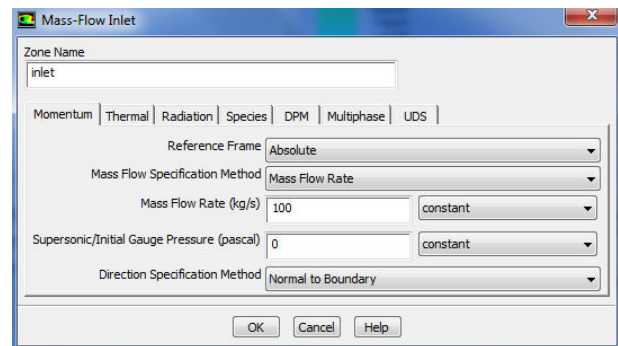
Temperature - T - (°C)	Density - ρ - (kg/m ³)	Specific Heat Capacity - Cp - (10 ³ J/kg.K)	Thermal Conductivity - k - (W/m K)	Kinematic Viscosity - ν - (10 ⁻⁶ m ² /s)	Prandtl Number - Pr -
-50	1547	0.875	0.067	0.310	6.2
-40	1519	0.885	0.069	0.279	5.4
-30	1490	0.896	0.069	0.253	4.8
-20	1461	0.907	0.071	0.235	4.4
-10	1429	0.920	0.073	0.221	4.0
0	1397	0.935	0.073	0.214	3.8
10	1364	0.950	0.073	0.203	3.6
20	1330	0.966	0.073	0.198	3.5
30	1295	0.984	0.071	0.194	3.5
40	1257	1.002	0.069	0.191	3.5
50	1216	1.022	0.069	0.190	3.5

R12 PROPERTIES

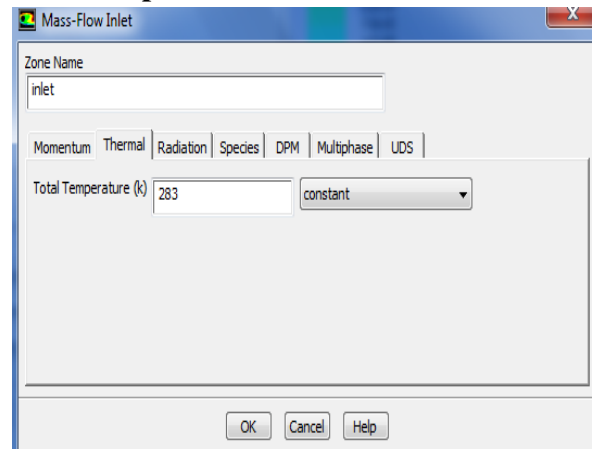


INLET BOUNDARY CONDITIONS

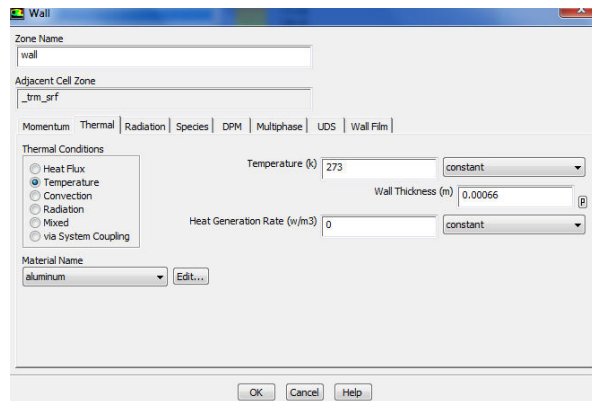
Inlet



Inlet Temperature

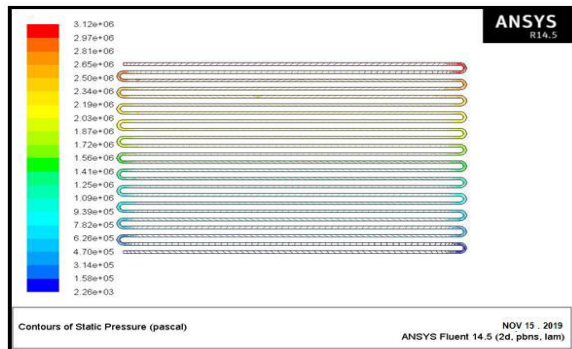


Wall

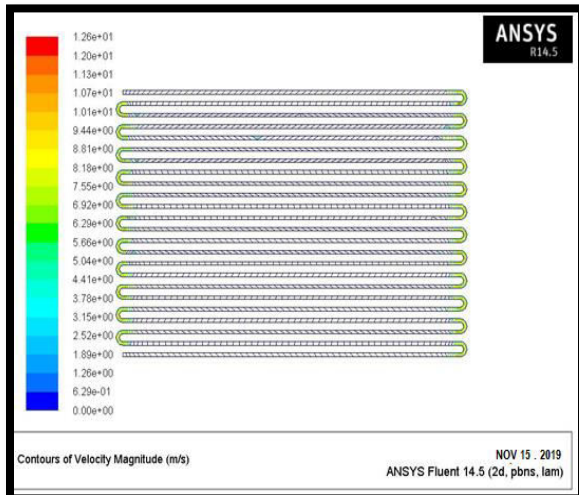


Solution → Solution Initialization → Hybrid Initialization → done
 Run calculations → no of iterations = 100 → calculate → calculation complete
 → → Results → graphics and animations → contours → setup

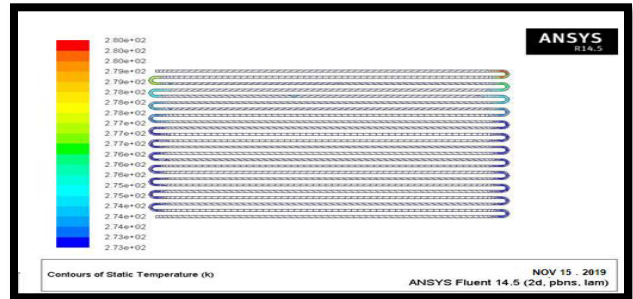
Iteration



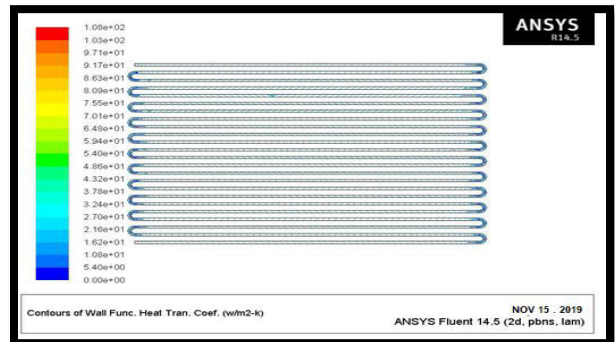
Contours of Static Pressure



Contours of Velocity Magnitude



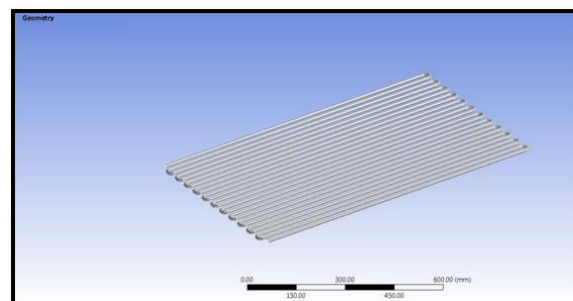
Contours of Static Temperature



FLUID - R12

Open work bench 14.5 > select **steady state thermal** in analysis systems > select geometry > right click on the geometry > import geometry > select IGES file > open

Imported model



ALUMINIUM 1060 MATERIAL PROPERTIES

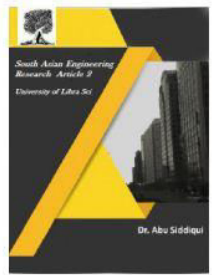
Thermal conductivity of aluminum = 15.1W/mk

Specific heat = 356J/Kg K

Density = 0.00000412 Kg/mm³

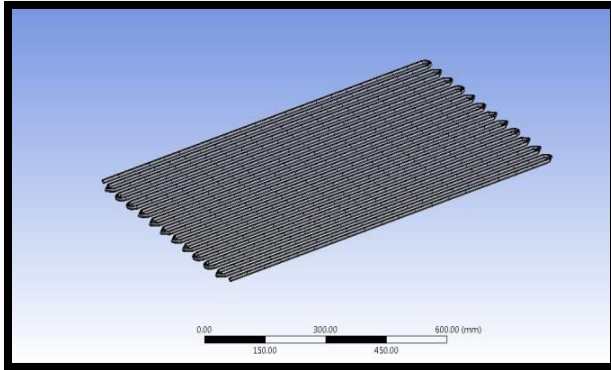


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Model >right click>edit>select generate mesh

Meshed model



Boundary conditions

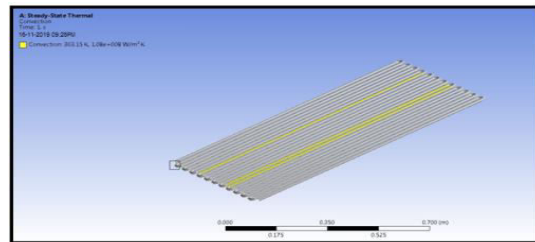
Select steady state thermal >right click>insert>

Select steady state thermal >right click>insert>select heat flux

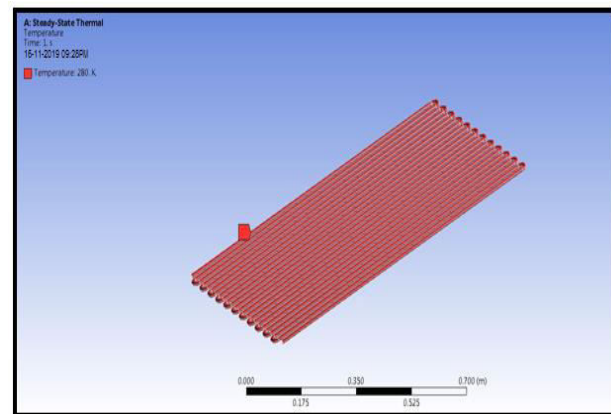
Select steady state thermal >right click>solve

Solution>right click on solution>insert>select temperature

Convection

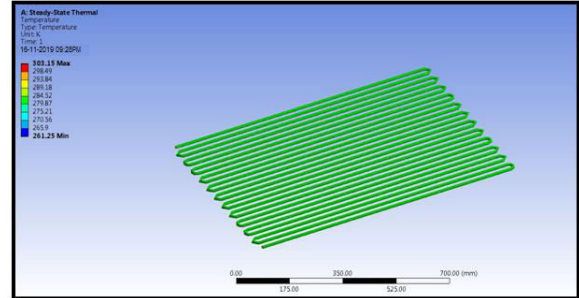


Temperature

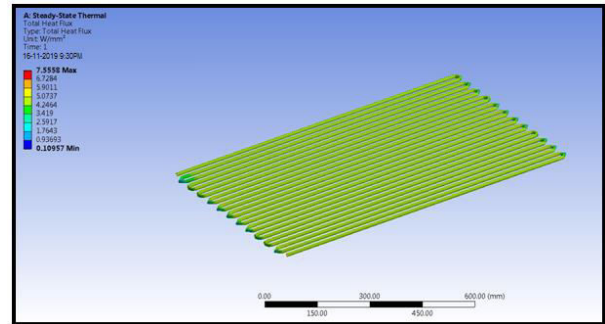


Results

Temperature

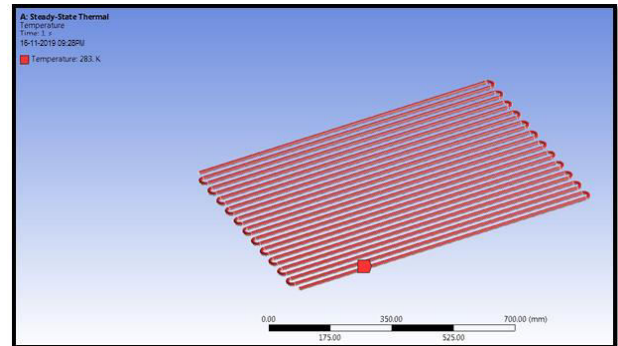


Heat flux

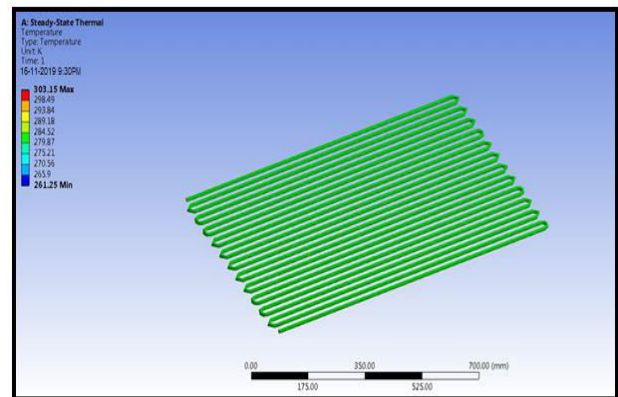


FLUID - R22

Temperature

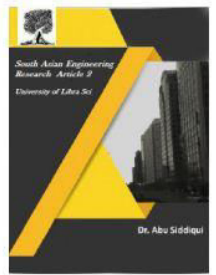


Temperature

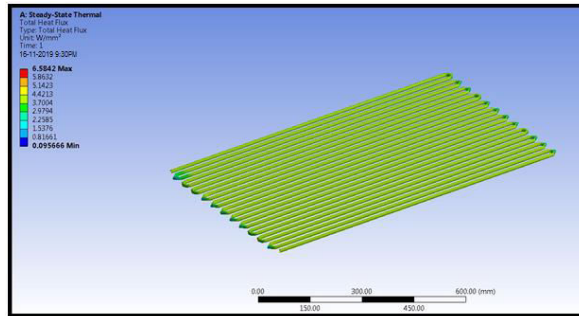




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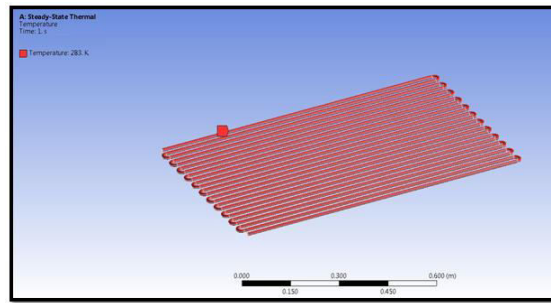


Heat flux

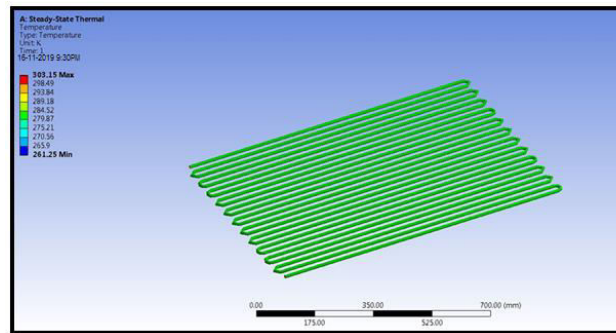


FLUID - R407C

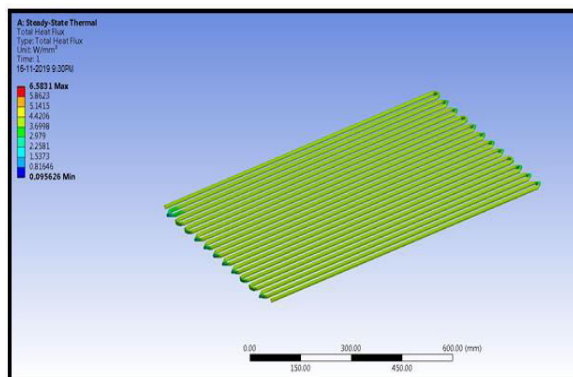
Temperature



Temperature



Heat flux



MATERIAL –ALUMINIUM 1100

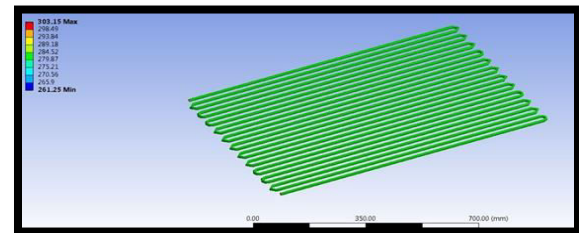
FLUID - R12

Thermal conductivity of aluminum = 59.1 W/mK

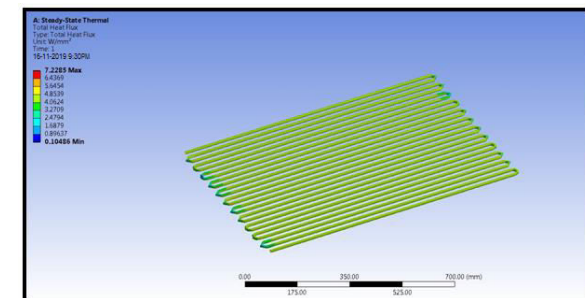
Specific heat = 421 J/Kg K

Density = 0.00000771 Kg/mm³

Temperature

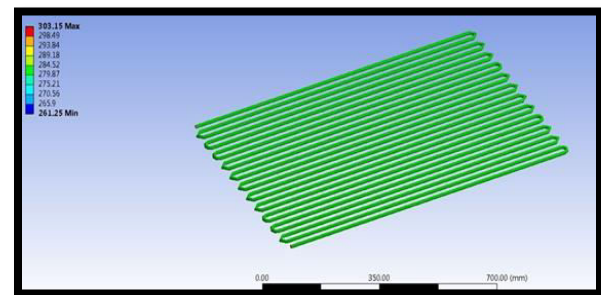


Heat flux

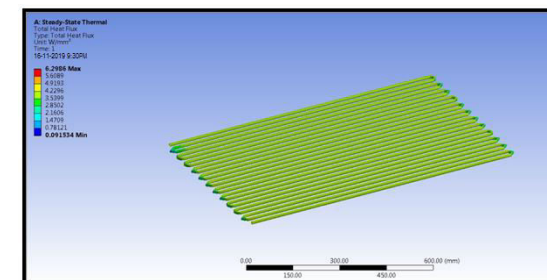


FLUID - R22

Temperature

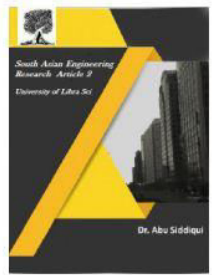


Heat flux



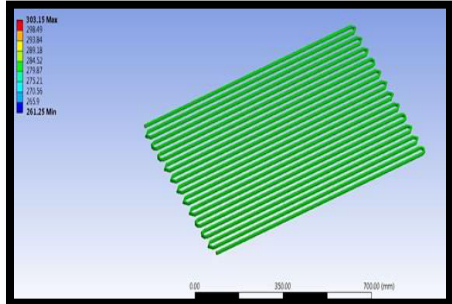


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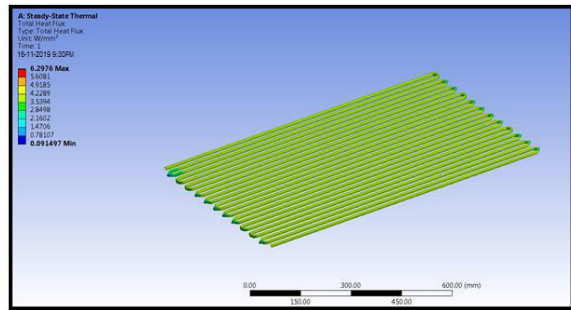


FLUID - R407C

Temperature

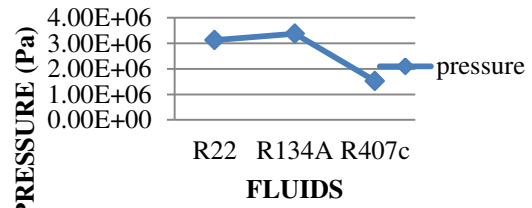


Heat flux



					9	
R2	3.3	2.83e	1.3	1.56	0.01	-
2	7e ⁺	+02	6e ⁺	e ⁺	3374	181.
	06		01	02	329	787
						11
R4	1.5	2.83e	1.4	1.47	-	-
07	2e ⁺	+02	7e ⁺	e ⁺	0.01	48.7
C	06		01	02	4236	041
					45	02

COMPARISON OF PRESSURE VALUES FOR DIFFERENT FLUIDS

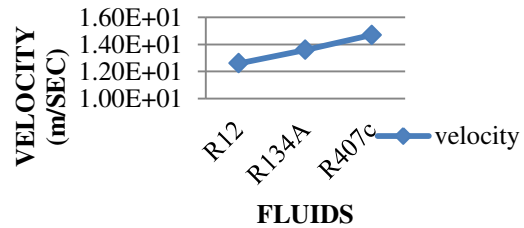


RESULTS AND DISCUSSION

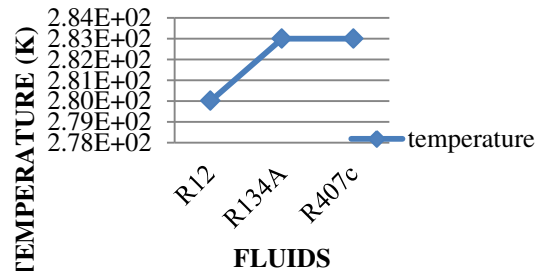
CFD ANALYSIS

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)
R1	3.1	2.80e	1.2	1.08	-	855.
2	2e ⁺	+02	6e ⁺	e ⁺	0.02	549
	06		01	02	7842	

COMPARISON OF VELOCITY VALUES FOR DIFFERENT FLUIDS

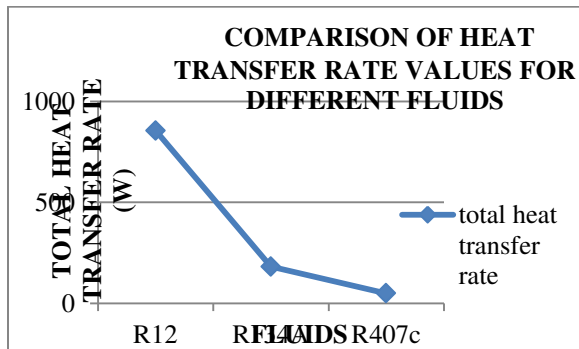
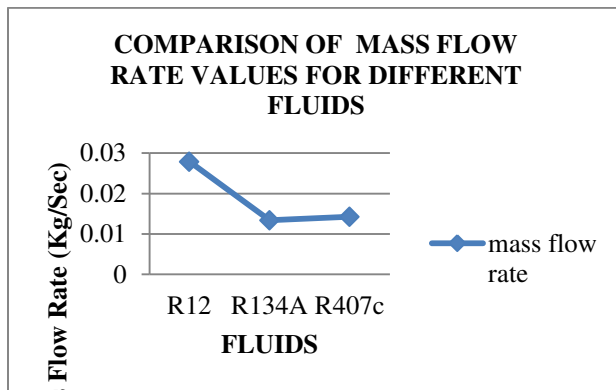
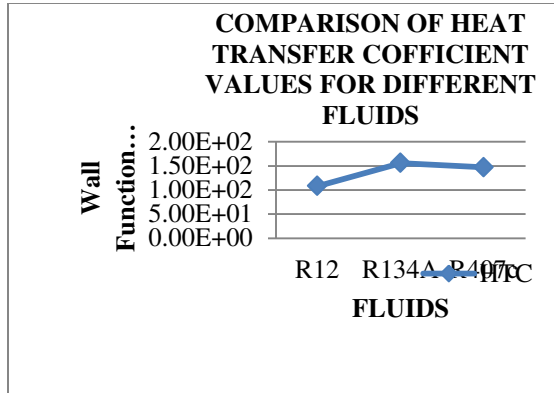
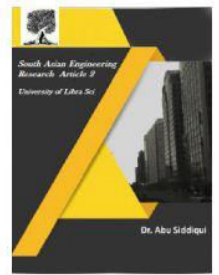


COMPARISON OF TEMPERATURE VALUES FOR DIFFERENT FLUIDS





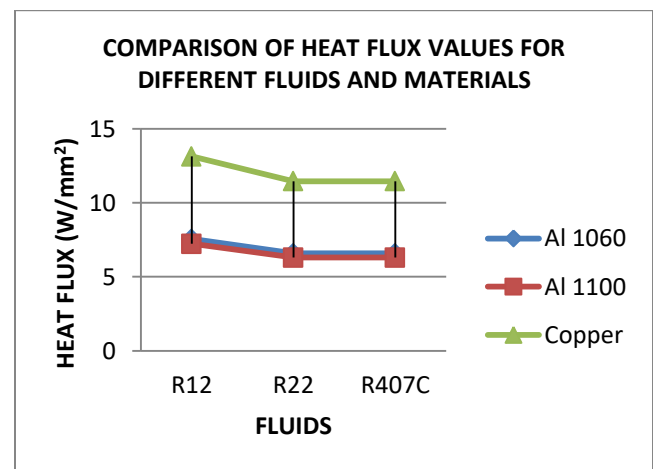
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THERMAL ANALYSIS

Material s	Flu ids	Conve ction (W/m ² K)	Temper ature (°C)	Heat flux (W/ mm ²)
ALUMI NIUM 1060	R1 2	108	303.15	7.555 8
	R2 2	156	303.15	6.584 2

ALUMI NIUM 1100	R4 07c	147	303.15	6.583 1
	R1 2	108	303.15	7.228 5
	R2 2	156	303.15	6.298 6
COPPE R	R4 07c	147	303.15	6.297 6
	R1 2	108	303.15	13.13 7
	R2 2	156	303.15	11.45 7
	R4 07c	147	303.15	11.45 4



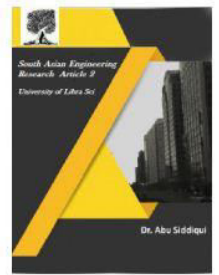


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CONCLUSION

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, R22 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 R22 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 R22 and material Copper is used.

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