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CFD AND THERMAL ANALYSIS ON AC CONDENSER BY USING DIFFERENT FLUIDS AND DIFFERENT MATERIAL

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ABSTRACT

Air conditioning systems have condenser that removes unwanted heat from the refrigerant and transfers that heat outdoors. The primary component of a condenser is typically the condenser coil, through which the refrigerant flows. 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 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 Aluminium alloys 6061 and 7075. The refrigerants varied will be R 22, R 134 and R407C. CFD analysis is done to determine temperature distribution and heat transfer rates by varying the refrigerants. Heat transfer analysis is done on the condenser to evaluate the better material.
3D modelling is done in CREO and analysis is done in ANSYS.

Keywords: Condensor, ANSYS, CREO, Thermal analysis

1. INTRODUCTION

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 so doing, 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 **condenser unit** used in central air conditioning systems typically has a heat exchanger section to cool down and condense incoming refrigerant vapor into liquid, a compressor to raise the pressure of the refrigerant and move it along, and a fan for blowing outside air through the heat

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exchanger section to cool the refrigerant inside. A typical configuration of such a condenser unit is as follows: The heat exchanger section wraps around the sides of the unit with the compressor inside. In this heat exchanger section, the refrigerant goes through multiple tube passes, which are surrounded by heat transfer fins through which cooling air can move from outside to inside the unit. There is a motorized fan inside the condenser unit near the top, which is covered by some grating to keep any objects from accidentally falling inside on the fan. The fan is used to blow the outside cooling air in through the heat exchange section at the sides and out the top through the grating. These condenser units are located on the outside of the building they are trying to cool, with tubing between the unit and building, one for vapor refrigerant entering and another for liquid refrigerant leaving the unit. Of course, an electric power supply is needed for the compressor and fan inside the unit.

- **Direct contact condenser**

In this type of condenser, vapors are poured into the liquid directly. The vapors lose their latent heat of vaporization; hence, vapors transfer their heat into liquid and the liquid becomes hot. In this type of condensation, the vapor and liquid are of same type of substance. In another type of direct contact condenser, cold water is sprayed into the vapour to be condensed.

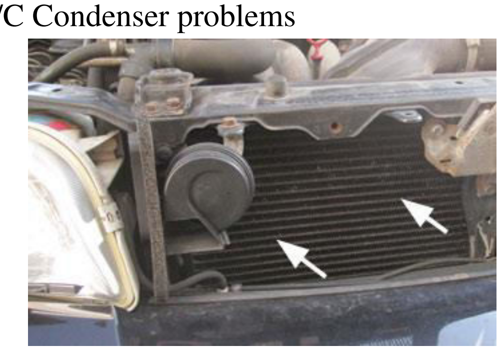
Other Types of Condensers

the world of Heating, Ventilation, and Air Conditioning (HVAC), condensers happen to be a topic of great importance. Instead of confusing information, the goal is to provide some basic information on the different types of condensers and their applications.

There are three other condensers used in HVAC systems

- **Water-cooled**
- **Air-cooled**
- **Evaporative**

A/C Condenser problems

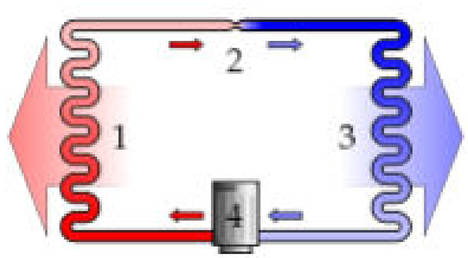


The A/C condenser is installed in front of the vehicle, so it often gets damaged in a frontal collision or by rocks or other objects on the road. Corrosion is another enemy of an A/C condenser, especially In the places where salt is used on roads in winter months. If a condenser is damaged, the refrigerant leaks out and the air conditioning system stops working. A damaged A/C condenser cannot be repaired and must be replaced. One of the signs of a leaking A/C condenser is an oily greenish residue around the impacted area. Sometimes a leak might be at the place of connection with one of the air conditioning system lines. Automotive repair shops use special equipment to find refrigerant leaks in an air conditioning system. Another issue with the A/C condensers is when the fins get clogged up with leaves and other debris. This reduces the air flow through the condenser fins and affects the efficiency of an air conditioning system.

Air Conditioning System

A simple stylized diagram of the refrigeration cycle:

1) Condensing coil,
2) Expansion valve,
3) Evaporator coil,
4) Compressor.



Refrigeration cycle

In the refrigeration cycle, a heat pump transfers heat from a lower-temperature heat source into a higher-temperature heat sink. Heat would naturally flow in the opposite direction. This is the most common type of air conditioning. A refrigerator works in much the same way, as it pumps the heat out of the interior and into the room in which it stands. This cycle takes advantage of the way phase changes work, where latent heat is released at a constant temperature during a liquid/gas phase change, and where varying the pressure of a pure substance also varies its condensation/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 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).

2.COOLING LOAD CALCULATIONS

Width = 2.94m
Length = 9.06m
Height = 2.47m
Window = 1.36 × 1
Wall thickness = 0.25m
Door sizes = 0.8 × 1
East wall = 9.06 × 2.47 = 22.3
West wall = 9.06 × 2.47 = 22.3
South wall = 2.94 × 2.47 = 7.2
North wall = 2.94 × 2.47 = 7.2
West door = 0.8 × 1.9 = 1
North window = 1.36 × 1.18 = 1.6
Bulbs = 6 × 40w = 240w
Floor volume = length × width × hei
= 9.06 × 2.94 × 2 = 65.791m³
Door area = w × h = 0.8 × 1.98 = 1.584
Wall thickness = 0.254m
No of systems = 20
Window area = 1.36 × 1.18 = 1.6048
No of windows = 1 = 1.6048m²
No of lights = 6 = 6 40 = 240w
Florescent coefficient = 1.25
Total lighting load = 240 × 1.25 = 300w
Solar heat gain factor = (SHGF)

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South wall = 140 w/m^2
North wall =120 w/m^2
West wall = 340 w/m^2
East wall = 60 w/m^2
Overall coefficient of heat transfer (U) w/m^{2}K

U_{wall} = 1.56 w/m^{2}K
U_{roof} = 5.675 w/K
U_{floor} = 159 w/K
U_{door} = 142 w/K
U_{window} = 4.70 w/m^{2}K

Equivalent temperature differences ( )
$t_e of north wall = 90^0$
$t_e of south wall = 11^0$
$t_e of west wall = 11^0$
$t_e of east wall = 6^0$
$t_e of roof = 19^0$
$t_e of floor = 2.4^0$

No of persons = 40
Sensible heat load per person = 117W
Latent heat load per person = 50w
Ventilation required per person = 0.28m^3/min
Out door conditions:
Dry bulb temperatures = 38^{0}C RH 60%
W_i 0.011 kg/kg of dry air ratio

3. 3D MODELING OF CONDENSER

THE MODEL IS DESIGNED FROM BASED ON JOURNEL OF PLATE-FIN-AND-TUBE CONDENSER PERFORMANCE AND DESIGN FOR REFRIGERANT R-410A AIR-CONDITIONER

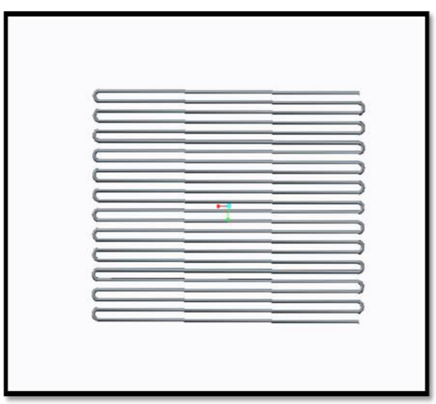

Fig - 3D Model

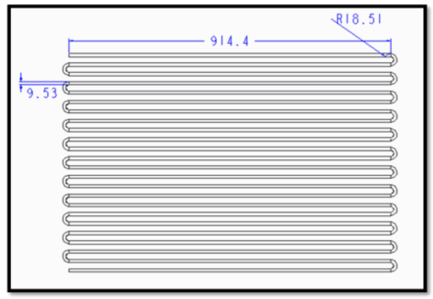

Fig – 2D Drafting

4. 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

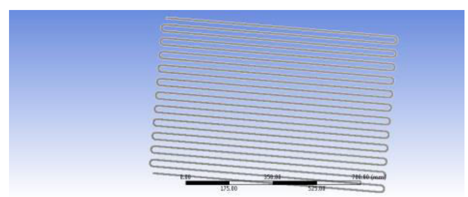

Fig - Imported model from Creo 2.0

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

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

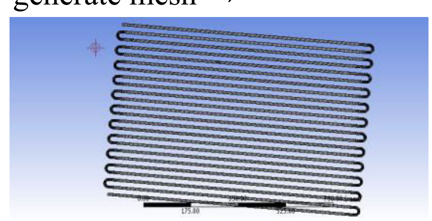

Fig – Meshed Model

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SPECIFYING BOUNDARIES FOR INLET AND OUTLET

Inlet

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

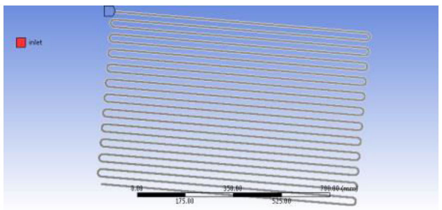


Fig – Fluid inlet

Outlet

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

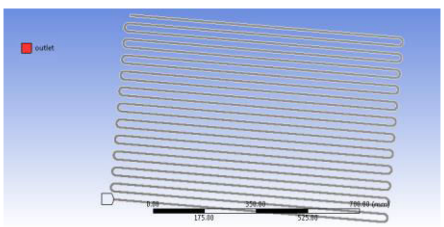
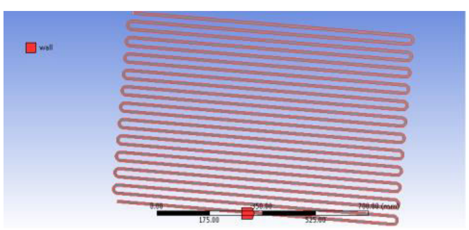


Fig – Fluid outlet

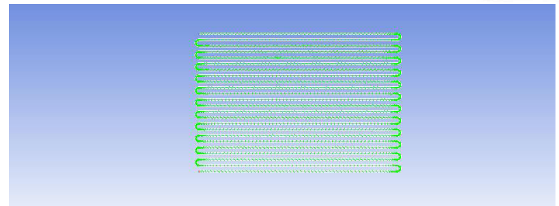
Wall



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

FLUID - R22

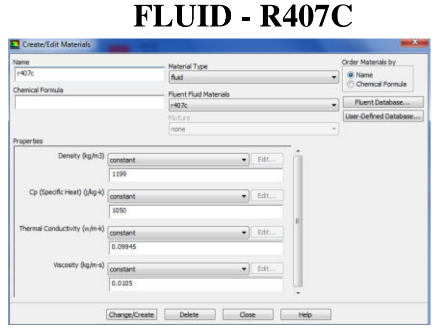
Temperature - T - (°C)	Density - ρ - (kg/m³)	Specific Heat Capacity - c_p - (10^3 J/kg.K)	Thermal Conductivity - k - (W/m K)	Kinematic Viscosity - ν - (10^{-6} m²/s)	Prandtl Numbe - Pr -
-50	1547	0.875	0.067	0.310	6.2
-40	1519	0.885	0.069	0.279	5.4
-30	1490	0.896	0.069	0.253	4.8
-20	1461	0.907	0.071	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

FLUID - R134A

R-134a Properites - SI Units

Temperature (°C)	Absolute Pressure (bar)	Density Liquid (kg/m³)	Density Vapor (kg/m³)	Enthalpy Liquid (kJ/kg)	Enthalpy Vapor (kJ/kg)	Entropy Liquid (kJ/(kgK))	Entropy Vapor (kJ/(kgK))
-60	0.15935	1472.0	0.9291	24.491	261.491	0.68772	1.8014
-50	0.29477	1444.9	1.6526	36.302	267.779	0.74358	1.7809
-40	0.51225	1417.0	2.773	48.631	274.068	0.79756	1.76448
-30	0.84379	1388.2	4.4307	61.130	280.324	0.84995	1.75142
-20	1.32719	1358.4	6.7903	73.833	286.513	0.901	1.74113
-10	2.00575	1327.4	10.047	86.777	292.598	0.95095	1.73309
0	2.,92769	1295.1	14.433	1000.0	298.536	1	1.72684
10	4.14571	1261.2	20.226	113.540	304.276	1.04834	1.72196
20	5.71665	1225.5	27.773	127.437	309.756	1.09613	1.71806
30	7.70132	1187.5	37.517	141.736	314.892	1.14354	1.71473
40	10.1648	1146.7	50.055	156.491	319.575	1.19073	1.71152
50	13.1773	1102.2	66.234	171.778	323.652	1.23794	1.70792
60	16.8156	1052.9	87.346	187.715	326.896	1.28548	1.70325
70	21.1668	996.49	115.564	204.515	328.941	1.3339	1.6965
80	26.3336	928.78	155.130	222.616	329.095	1.38434	1.68585
90	32.4489	838.51	216.936	243.168	325.655	1.43978	1.66692
100	39.7254	649.71	367.064	273.641	309.037	1.5198	1.61466

FLUID - R407C



5. THERMAL ANALYSIS

MATERIAL – ALUMINIUM 6061

FLUID –R22

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

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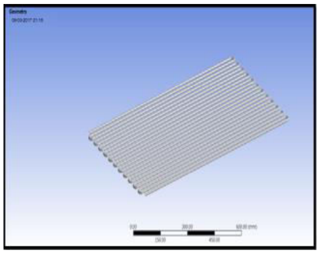
geometry>import geometry>select **IGES** file>open

Imported model



ALUMINIUM 6061 MATERIAL PROPERTIES

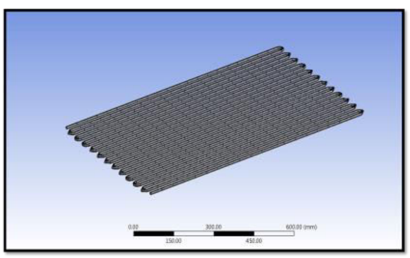
Thermal conductivity of aluminum = 15.1W/mk

Specific heat =356J/Kg K

Density = 0.00000412 Kg/mm^3

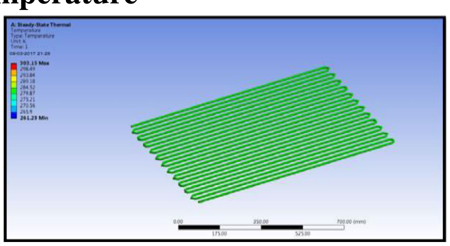
Model >right click>edit>select generate mesh

Meshed model

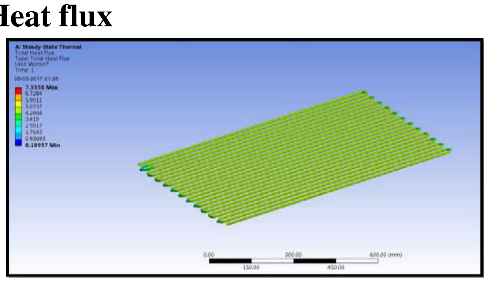


Results

Temperature

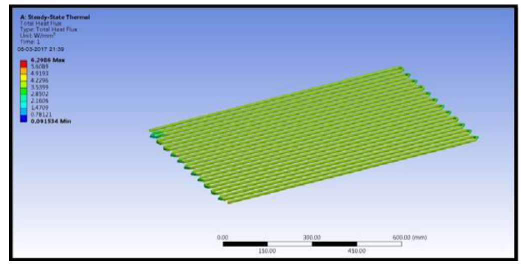


Heat flux



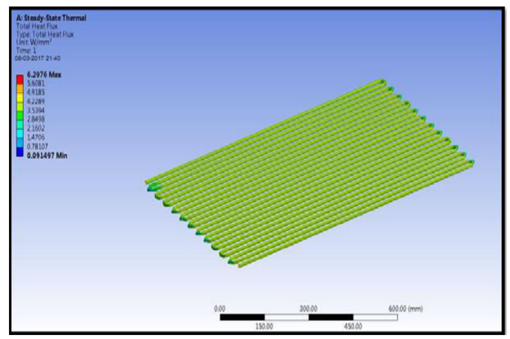
FLUID - R134A

Heat flux



FLUID - R407C

Heat flux



MATERIAL –COPPER

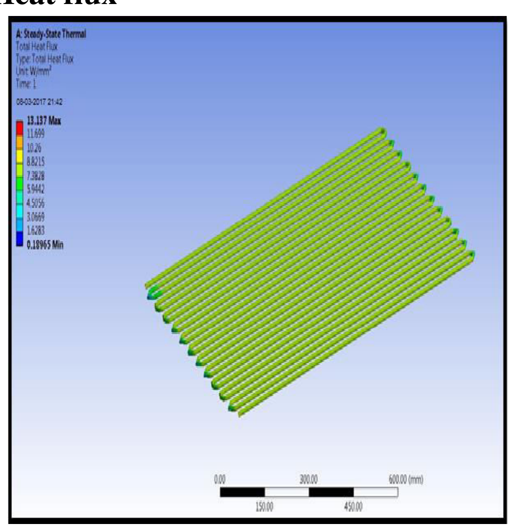
FLUID –R22

Thermal conductivity of aluminum = 59.1W/mK

Specific heat =421 J/Kg K

Density = 0.00000771Kg/mm^3

Heat flux



FLUID - R407C

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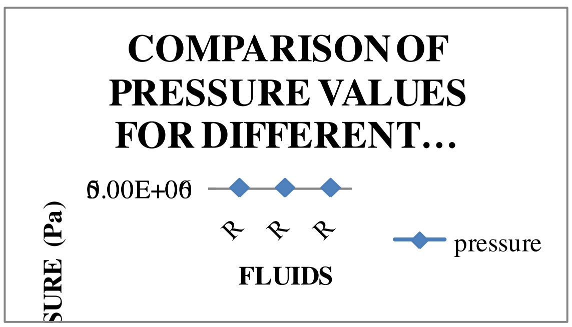
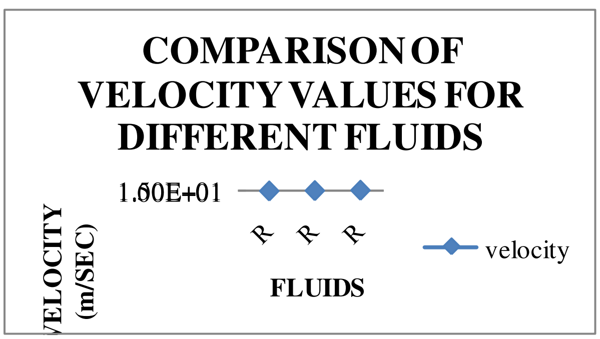
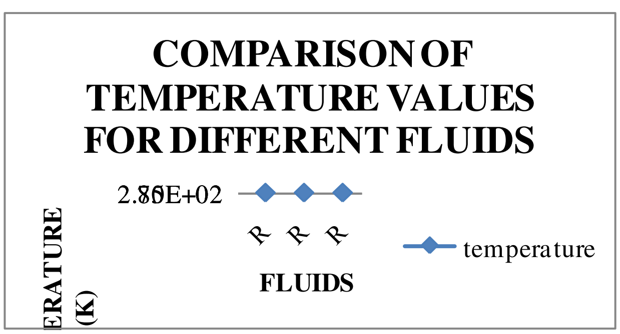
6. RESULTS AND DISCUSSION

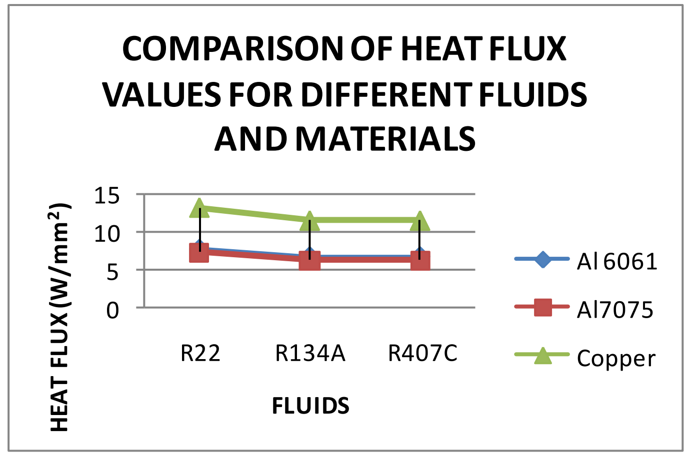
CFD ANALYSIS

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)
R22	$3.12e^{+06}$	$2.80e^{+02}$	$1.26e^{+01}$	$1.08e^{+02}$	-0.0278429	855.549
R134A	$3.37e^{+06}$	$2.83e^{+02}$	$1.36e^{+01}$	$1.56e^{+02}$	0.013374329	-181.78711
R407C	$1.52e^{+06}$	$2.83e^{+02}$	$1.47e^{+01}$	$1.47e^{+02}$	-0.01423645	-48.704102









7. CONCLUSION

In this thesis heat transfer by convection in ACby 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 6061 and 7075. The refrigerants varied will be R 22, R 134 and R407C. CFD analysis is done to determine temperature distribution and heat transfer rates by varying the refrigerants. Heat transfer analysis is done on the condenser to evaluate the better material.

By observing CFD analysis results, the heat transfer coefficient is more when R134A is used and heat transfer rate is more when R22 is used than other fluids.By observing thermal analysis results, the heat flux is more when R22 is used and when material Copper is used. (i.e) The heat transfer rate is more when fluid R134A and material Copper is used.

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