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DESIGN AND ANALYSIS OF CONDENSER USING 3D MODELING SOFTWARE

A. Harsha Vardhan Reddy[1], G.Rajasekhar Reddy[2], G.Phanindra[3], K. Vijay Kumar[4]

[1]*Asst. Professor, Mechanical, Gurunanak Institutions, Telangana, India*
[2]*Student, mechanical, Gurunanak Institutions, Telangana, India*
[3]*Student, mechanical, Gurunanak Institutions, Telangana, India*
[4]*Student, mechanical, Gurunanak Institutions, Telangana , India*

Abstract

Refrigeration 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 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 refrigeration by varying the condenser length are determined by CFD and thermal analysis. The assessment is out on an air-cooled tube condenser of a vapour compression cycle for refrigeration system. The materials considered for tubes are Copper and Aluminum alloys. The refrigerants varied will be R 12. 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.

Keywords: *CREO, ANSYS, CFD, FEA*

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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 can be made according to numerous 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

Fig 1: Condenser of refrigerator

1.1 Types of Condensers

- Direct contact condenser
- Water-cooled
- Air-cooled
- Evaporative

1.2 Block Diagram of a Condencer

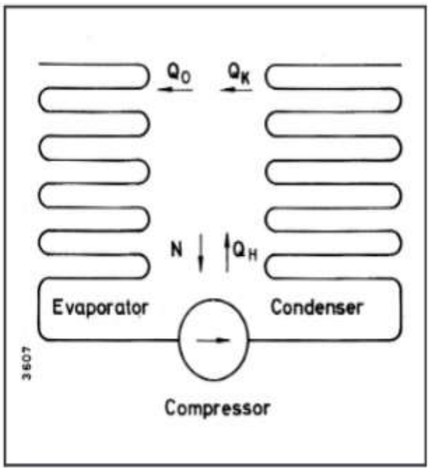

Fig 2: Block diagram

2. LITERATURE REVIEW

A comprehensive review of the literature on Vapor Absorption Systems, Compression-Absorption System and Vapor Compression System has been carried out on various aspects of energy analysis, the type of cycles analyzed, working pairs used and energy analysis. With regards to

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vapor absorption cycles, it is found that mostly the studies are carried out on large capacity systems and the investigation had been carried out with in a limited range of system design parameters. The literature on small vapor absorption systems is scant and very few studies have been done on smaller systems. The above studies are simulation studies. Regarding compression-absorption systems studies have been carried out by many researchers mostly analytically and experimentally. The investigations have been done on wet compression cycles which eliminated the need of solution pump. The literature provides details with regard to the applications.

3. 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 Model

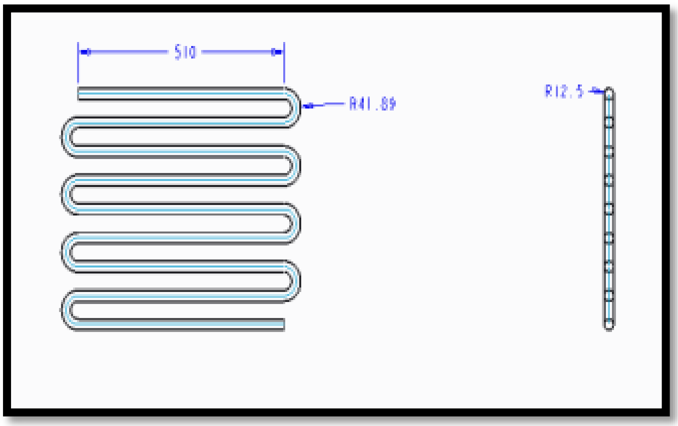

Fig 3: 3D MODEL

4. 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.

Fluid Dynamics

ANSYS Fluent, CFD, CFX, FENSAP-ICE and related software are Computational Fluid Dynamics software tools used by engineers for design and analysis.

4.1 Thermal Analysis of Condenser

4.1.1 Condenser Length-345mm

Material-Aluminum Alloy

Imported Model

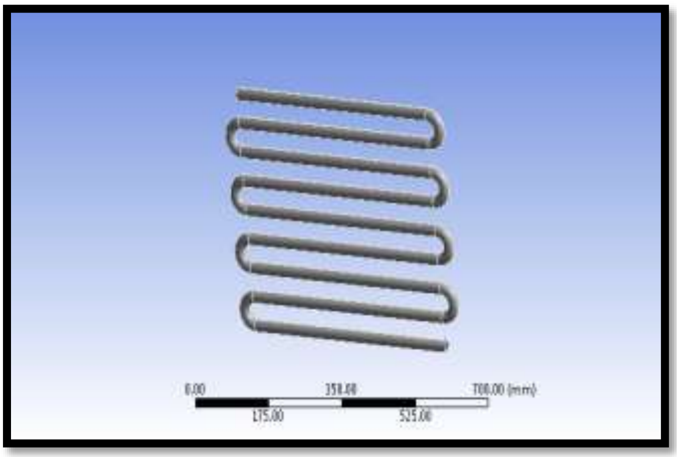

Fig 5: Imported Model

Meshed Model

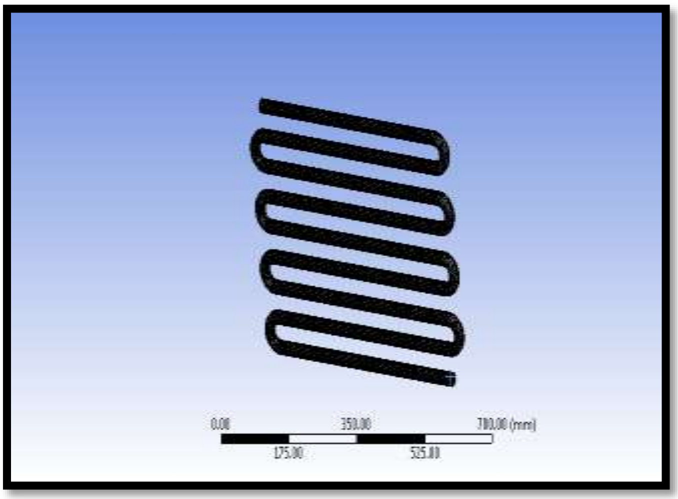

Fig 6*:* Meshed Model

Finite element analysis or FEA representing a real project as a “mesh” a series of small, regularly shaped tetrahedron connected elements, as shown in the above fig.

BOUNDARY CONDITIONS
T =278K

Temperature

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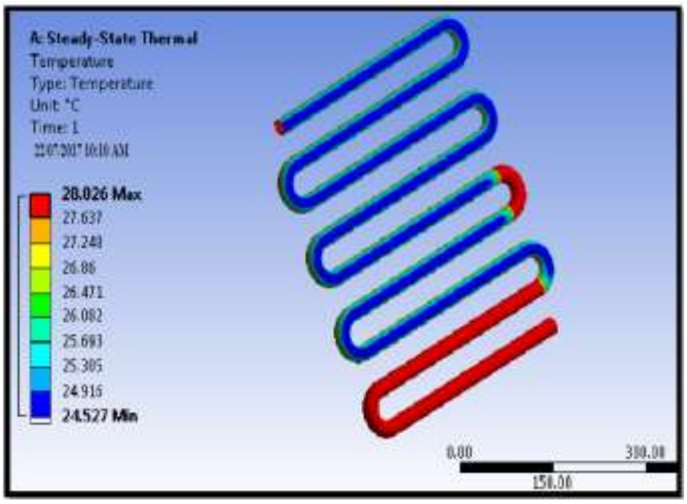

Fig 7: TEMPERATURE

Heat Flux

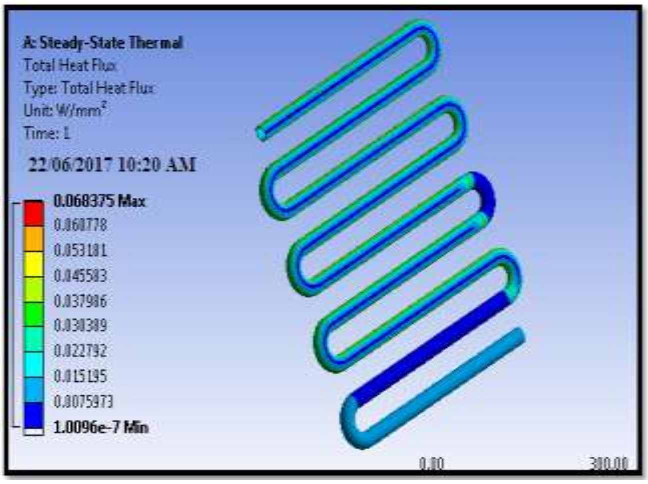

Fig 8: HEAT FLUX

Material -Copper

Temperature

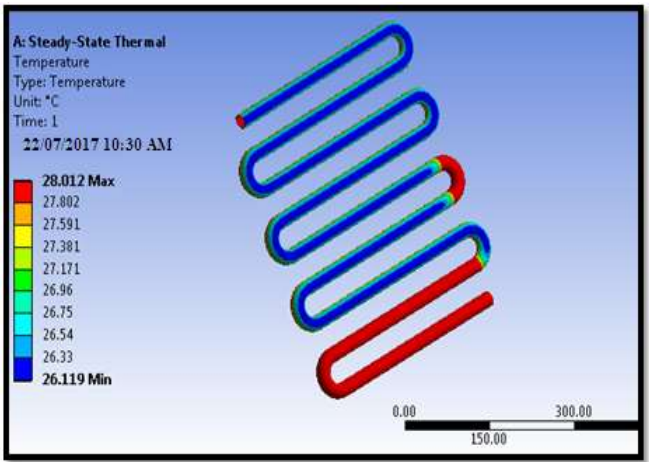

Fig 9: TEMPERATURE

Heat Flux

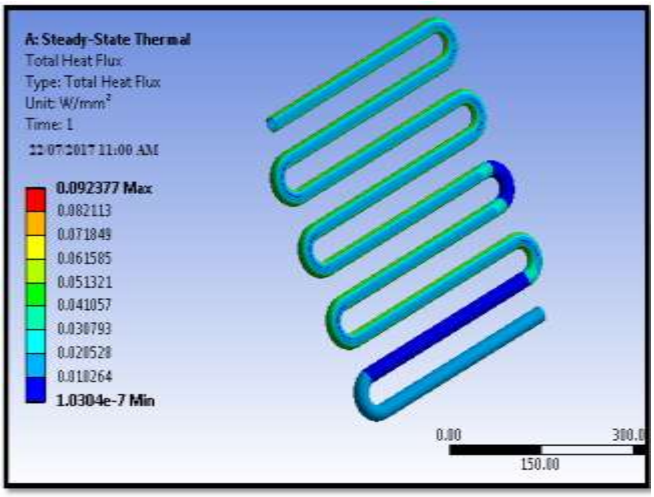

Fig 10: HEAT FLUX

4.1.2 Condenser Length-405mm

Material -Aluminum

Temperature

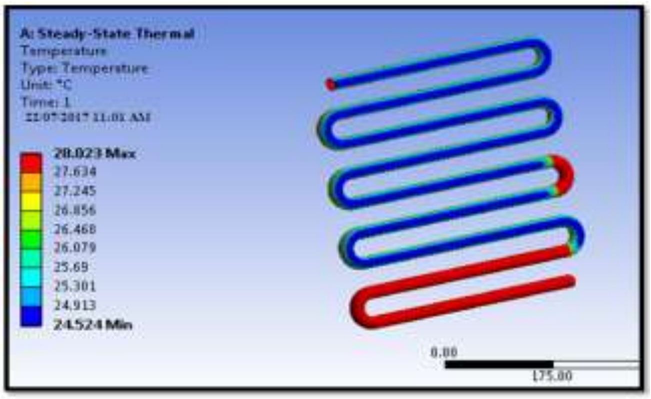

Fig 11*:* TEMPERATURE

Heat Flux

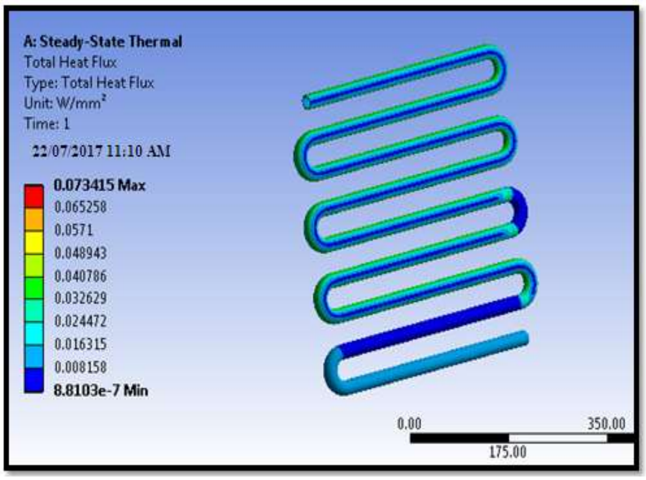

Fig 12: HEAT FLUX

Material -Copper

Temperature

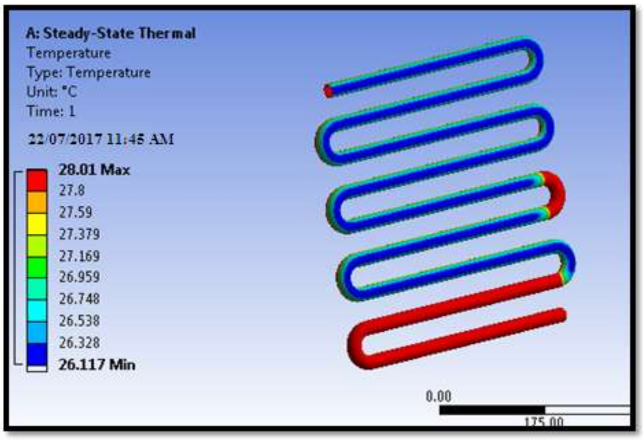

Fig 13: TEMPERATURE

Heat Flux

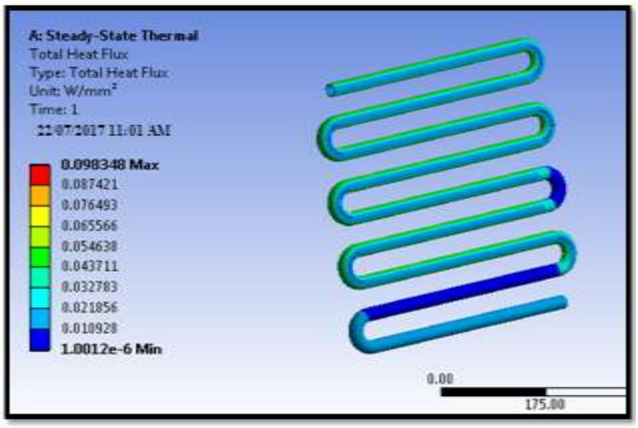

Fig 14: HEAT FLUX

4.1.3 Condenser Length-465mm

Material -Aluminum

Temperature

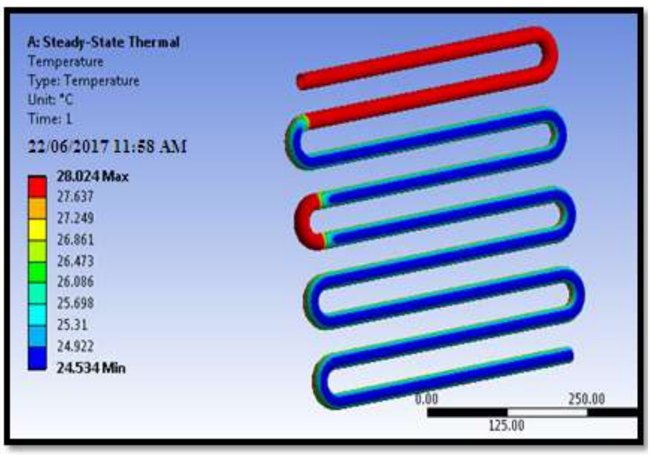

Fig 15: TEMPERATURE

Heat Flux

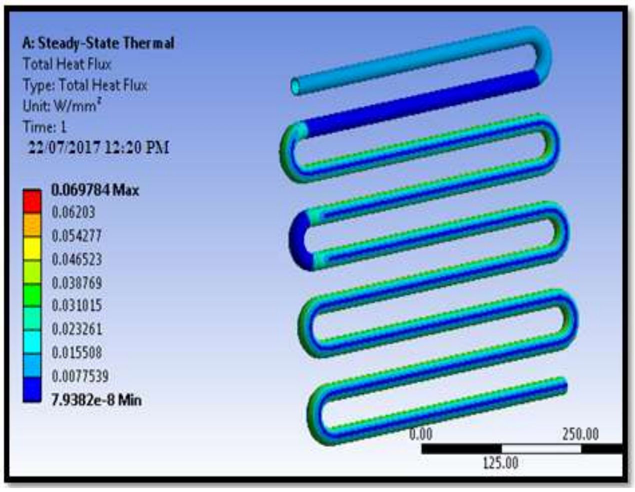

Fig 16: HEAT FLUX

Material -Copper

Temperature

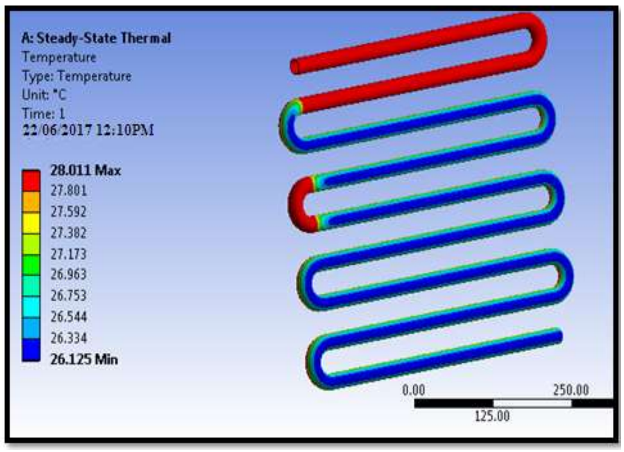

Fig 17: TEMPERATURE

Heat Flux

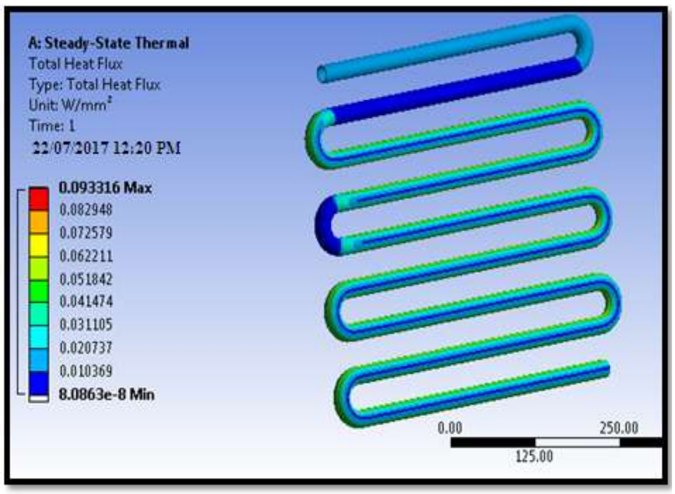

Fig 18: Heat Flux

4.2 CFD Analysis of Condenser

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4.2.1 At Condenser Length-345mm

Imported Model

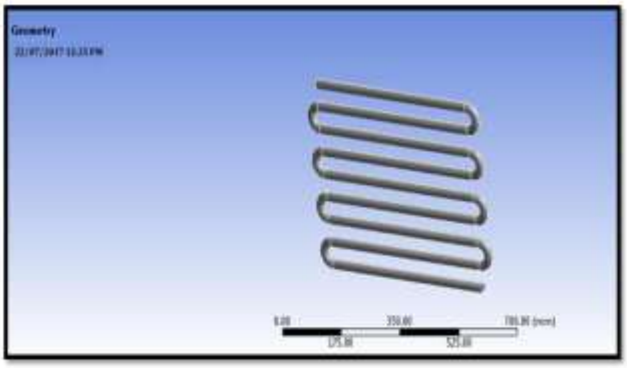

Fig 19: IMPORTED MODEL

MESHED MODEL

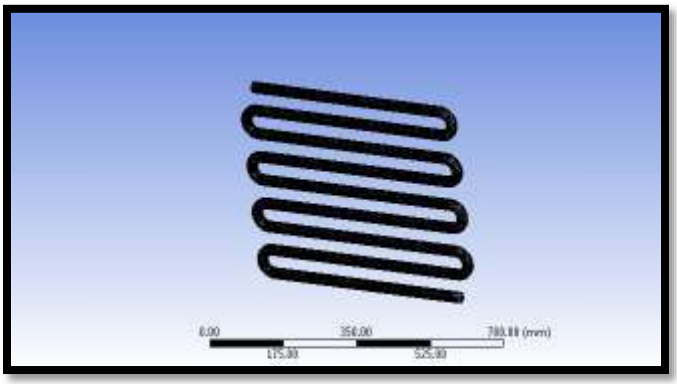

Fig 20: MESHED MODEL

Specifying the Boundaries for Inlet & Outlet

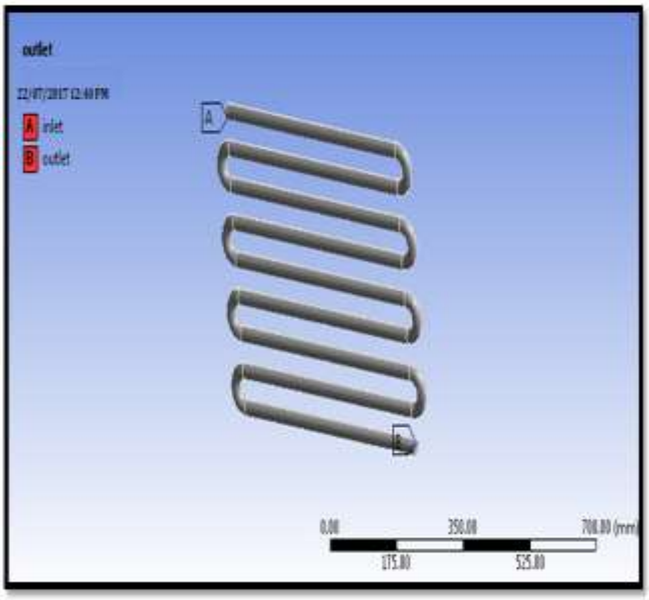

Fig 21: SPECIFYING THE BOUNDARIES FOR INLET & OUTLET

Temperature=278K

Pressure

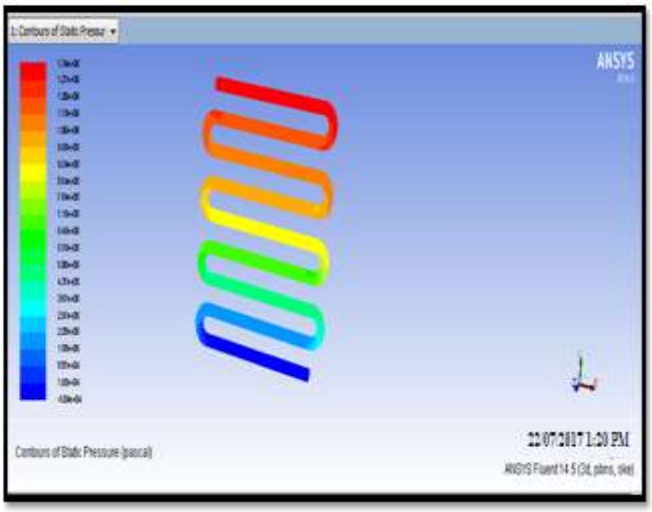

Fig 22: PRESSURE

Temperature

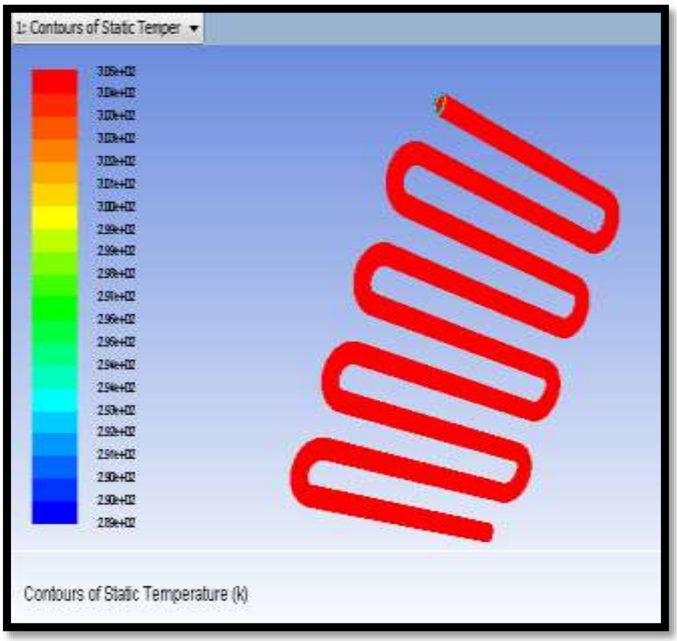

Fig 23: TEMPERATURE

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Heat Transfer Coefficient

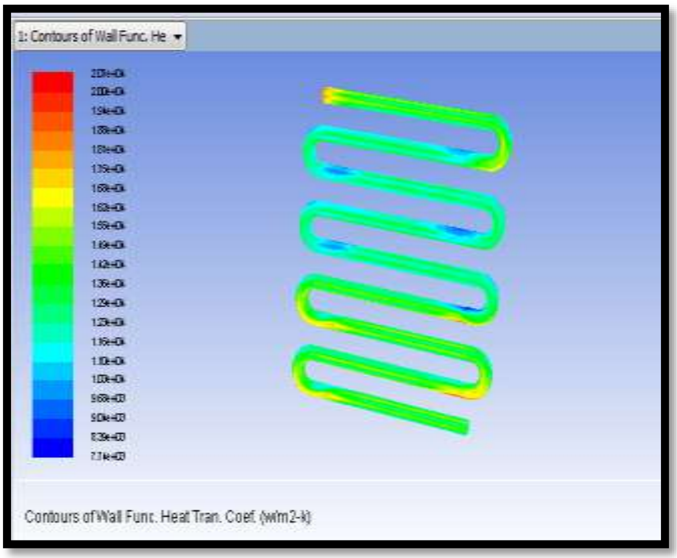

Fig 24: HEAT TRANSFER COEFFICIENT

Mass Flow Rate

Mass Flow Rate	(kg/s)
inlet	1.9999995
interior-____msbr	2209.5713
outlet	-1.9981513
wall-____msbr	0
Net	0.0018482208

Heat Transfer Rate

Total Heat Transfer Rate	(w)
inlet	-36353.133
outlet	-11344.112
wall-____msbr	46663.844
Net	-1033.4014

4.2.2 At Condenser Length-405mm

Pressure

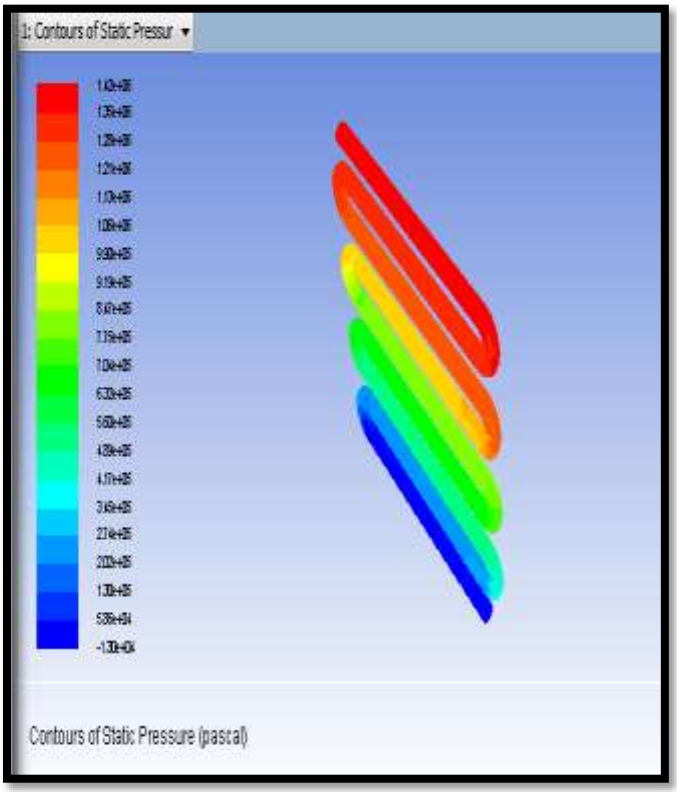

Fig 25: PRESSURE

Temperature

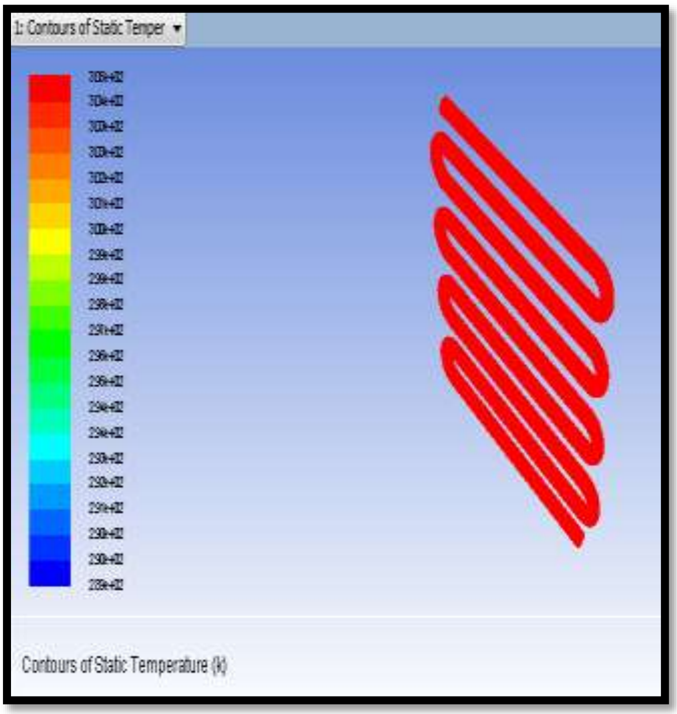

Fig 26: TEMPERATURE

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Heat Transfer Coefficient

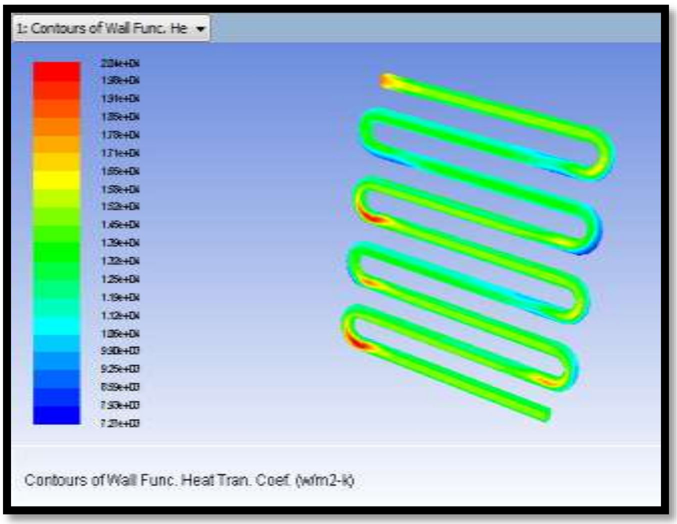

Fig 27: HEAT TRANSFER COEFFICIENT

Mass Flow Rate

Mass Flow Rate	(kg/s)
inlet	1.9999999
interior-____msbr	2544.5417
outlet	-2.0020876
wall-____msbr	0
Net	-0.0020877123

Heat Transfer Rate

Total Heat Transfer Rate	(w)
inlet	-36353.172
outlet	-11745.404
wall-____msbr	47533.996
Net	-564.58008

4.2.3 At Condenser Length-455mm

Pressure

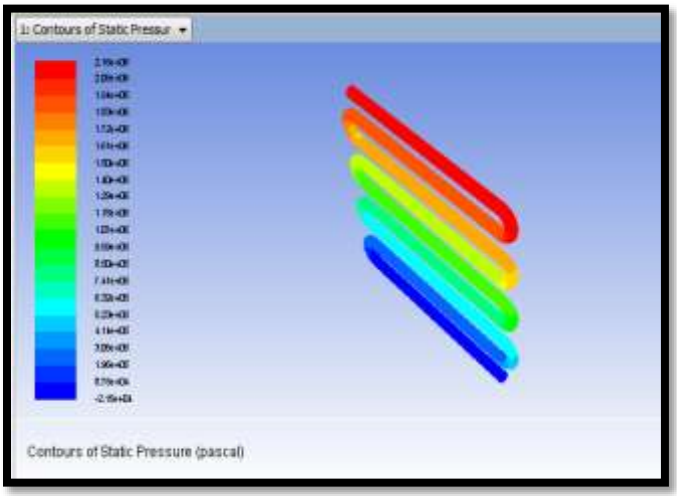

Fig 28: PRESSURE

Temperature

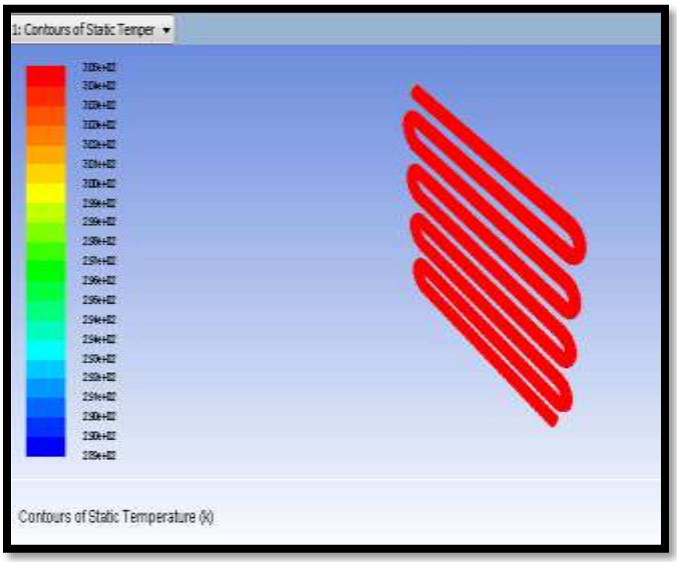

Fig 29: Temperature

Heat Transfer Coefficient

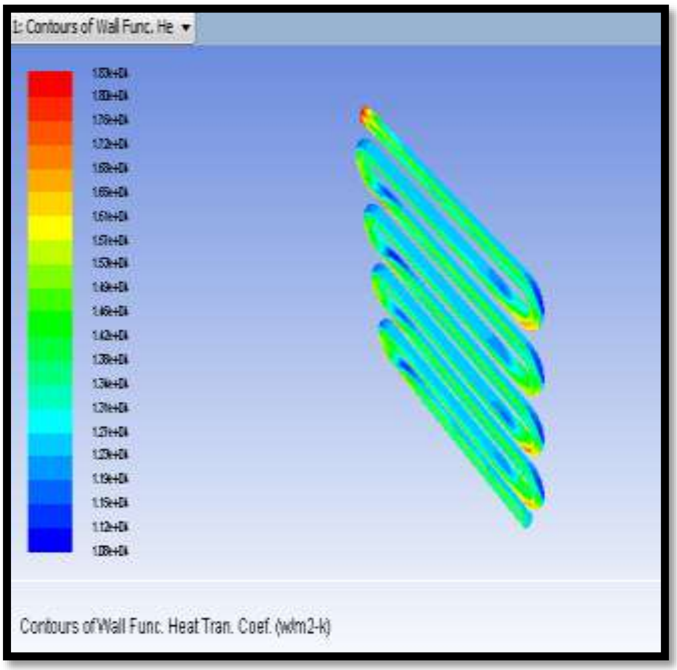

Fig 30: HEAT TRANSFER COEFFICIENT

Mass Flow Rate

Mass Flow Rate	(kg/s)
inlet	1.9999998
interior-____msbr	2815.469
outlet	-2.0120621
wall-____msbr	0
Net	-0.012062311

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Heat Transfer Rate

```
 Total Heat Transfer Rate                  (w)
-------------------------- --------------------
                    inlet           -36353.23
                   outlet          -12102.532
             wall-____msbr           47752.813
          ---------------- --------------------
                      Net           -702.9502
```

4.2.4 At Condenser Length-505mm

Pressure

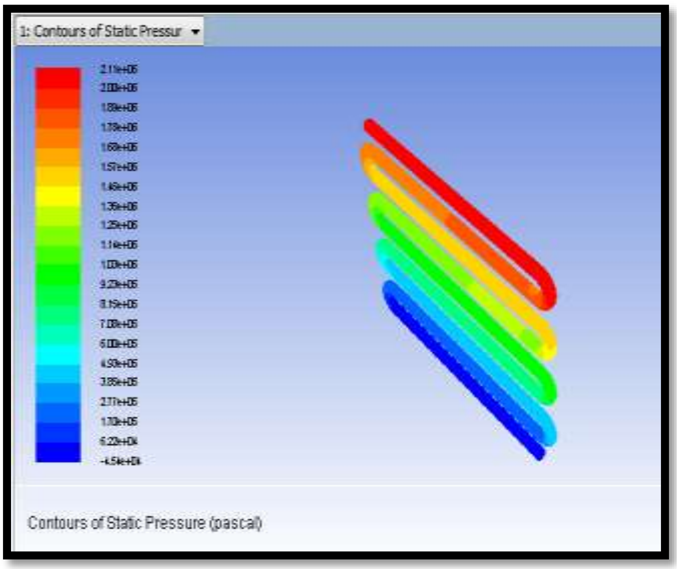

Fig 31: PRESSURE

Temperature

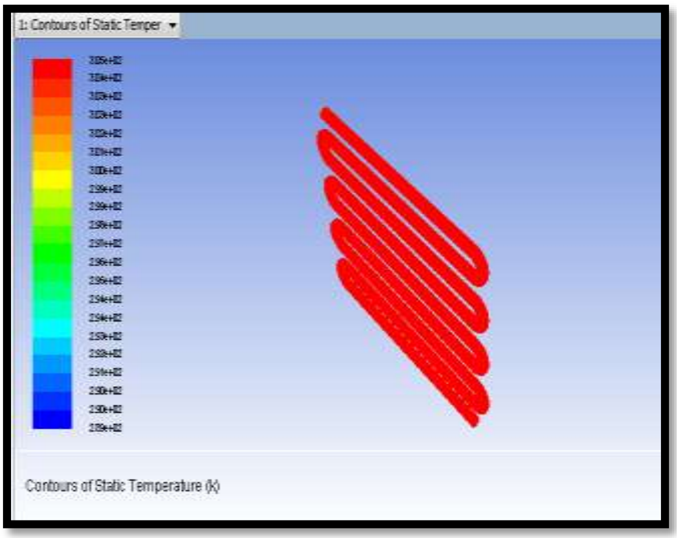

Fig 32: TEMPERATURE

Heat Transfer Coefficient

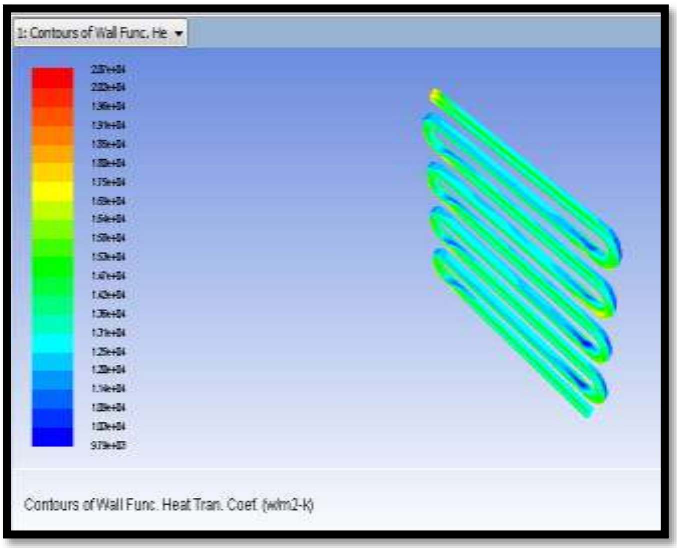

Fig 33: HEAT TRANSFER COEFFICIENT

Mass Flow Rate

```
         Mass Flow Rate                (kg/s)
-------------------- --------------------
                inlet                     2
    interior-____msbr             3092.1719
               outlet            -1.9881539
        wall-____msbr                     0
   ---------------- --------------------
                  Net           0.011846066
```

Heat Transfer Rate

```
 Total Heat Transfer Rate                  (w)
-------------------------- --------------------
                    inlet          -36353.117
                   outlet          -12102.339
             wall-____msbr           48077.563
          ---------------- --------------------
                      Net          -377.89355
```

RESULT TABLES

Table 1: Thermal Analysis

Material	Condenser length(mm)	Temperature (k)	Heat flux (w/mm^2)
Aluminum alloy	345	28.026	0.068375
	405	28.023	0.073415
	465	28.024	0.069784
	505	28.025	0.069883
Copper	345	28.012	0.092377
	405	28.01	0.098348
	465	28.011	0.093316
	505	28.015	0.093398

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TABLE 2: CFD Analysis

Condenser length (mm)	**Pressure(Pa)**	**Temperature (K)**	**Heat transfer coeffiecient (W/mm2k)**	**Mass flow rate(kg/sec)**	**Heat transfer rate (w)**
345	1.34e+06	3.05e+02	2.01e+04	0.001848208	1033.40
405	1.43e+06	3.05e+02	2.04e+04	0.002087713	564
455	2.15e+06	3.05e+02	1.83e+04	0.01262311	702.95

5. CONCLUSION

In this thesis heat transfer by convection in refrigeration by varying the condenser length are determined by CFD and thermal analysis. The assessment is out on an air-cooled tube condenser of a vapor compression cycle for refrigeration system.

The materials considered for tubes are Copper and Aluminum alloys. The refrigerants varied will be R 12. CFD analysis is done to determine temperature distribution and heat transfer rates.

In cfd analysis, the heat transfer confident more at condenser length 505mm.

In thermal analysis , the heat flux is more for copper material at condenser length 405mm.

So we can conclude that the better material is copper.

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