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Title: **FINITE ELEMENT ANALYSIS TO DETERMINE HEAT TRANSFER AND PRESSURE DROP INSIDE INTERNALLY HELICAL - GROOVED HORIZONTAL SMALL - DIAMETER TUBES**

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Paper Authors

S.RAVI TEJA, S. SUSHMA
Ellenki College Of Engineering &Technology, Hyderabad.

FINITE ELEMENT ANALYSIS TO DETERMINE HEAT TRANSFER AND PRESSURE DROP INSIDE INTERNALLY HELICAL - GROOVED HORIZONTAL SMALL - DIAMETER TUBES

[1]S.RAVI TEJA, [2]S. SUSHMA
[1]M.Tech Scholar, Thermal Engineering, Ellenki College Of Engineering &Technology, Hyderabad.
[2]Associate Professor,Ellenki College Of Engineering &Technology, Hyderabad.

ABSTRACT:

In general heat exchangers are large in size and extensive in size and heat exchange rate is also less and in traditional heat exchanger dead zone is deliver which diminishes the heat exchange rate and to make turbulence in ordinary heat exchanger some outside means is required and the liquid in regular heat exchanger is not in nonstop movement with each other. Tube in tube helical curl warm exchanger furnishes a smaller shape with its geometry offering more liquid contact and taking out the no man's land, expanding the turbulence and thus the heat exchange rate. Helical center to build the turbulence thus expands the heat exchange rate. The paper manages the pitch variety of the inward injured wire and its outcome on the heat exchange rate. This heat exchanger discovers its application generally in sustenance enterprises and waste heat recuperation Helical curl warm exchangers are broadly utilized as a part of mechanical applications, for example, control division, atomic power era, sustenance preparing plants, warm recuperation frameworks, refrigeration, nourishment industry, modern HVACs and so forth. General this heat dismissal rate depends is for the most part on different parameters for instance, surrounding air temperature, measurements of the loop, width of the curl. Regularly in household cooler condenser loop estimate is confined to some standard measurements. In this undertaking a condenser helical loop with various measurements are put set up of standard measurements of the curl. The examinations will be made by changing the blade stature and helix point. The CFD and Thermal examination will be completed for various refrigerants water, R32 and R410A for turbulent and laminar streams. Locate the warm practices of helical curls and assess which one best lastingness of helical loops and after discover the which is better condenser loop that one investigation utilizing deferent three materials like G Al Cu 4IMG 204, Aluminium Alloy Al99 and Magnesium compound this examination is carried on ansys programming, displaying is finished utilizing catia programming.

Keywords:refrigeratorhelicalshapecoils,CFD,thermalanalysis,catiadesignsansys

1. INTRODUCTION

Vapor pressure Refrigeration framework is an enhanced sort of air. The capacity of specific fluids to retain huge amounts of warmth as they vaporize is the premise of this framework. Contrasted with softening solids (say ice) to acquire refrigeration impact, vaporizing fluid refrigerant has more preferences. To say a couple, the refrigerating impact can be begun or ceased freely, the rate of cooling can be foreordained, the vaporizing temperatures can be administered by controlling the weight at which the fluid vaporizes. In addition, the vapor can be promptly gathered and dense once more into fluid state with the goal that same fluid can be recycled again and again to acquire refrigeration impact. In this way the vapor pressure framework utilizes a fluid refrigerant which dissipates and gathers promptly. The Vapor pressure refrigeration framework is presently a-days utilized for generally useful refrigeration. It is by and large utilized for all mechanical purposes from a little household icebox to a major aerating and cooling plant.

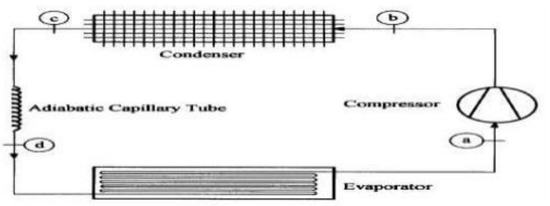


Fig.1.1Schematic diagram of a vapor compression refrigeration system

1.2 Types of Condensers In the realm of Heating, Ventilation, and Air Conditioning (HVAC), condensers happen to be a point of awesome significance. Rather than confounding data, the objective is to give some essential data on the diverse sorts of condensers and their applications.

There are three different condensers utilized as a part of HVAC frameworks.

- Water-cooled
- Air-cooled
- Evaporative

1.3Applications:

•**Air cooled** – If the condenser is situated outwardly of the unit, the air cooled condenser can give the most effortless course of action. These sorts of condensers launch warmth to the outside and are easy to introduce.Most regular uses for this condenser are local iceboxes, upright coolers and in private bundled aerating and cooling units. An incredible element of the air cooled condenser is they are anything but difficult to clean. Since earth can cause difficult issues with the condensers execution, it is very suggested that these be stayed far from soil.

•**Water cooled** – Although somewhat more expensive to introduce, these condensers are the more effective sort. Normally utilized for swimming pools and condensers channeled for city water stream, these condensers require consistent administration and support. They likewise require a cooling tower to save water. To anticipate erosion and the framing of green growth, water cooled condensers require a consistent supply of cosmetics water alongside water treatment. Contingent upon the application you can look over tube in tube, shell and curl or shell and tube condensers. All are basically made to deliver a similar result, yet each in an unexpected way.

•**Evaporative** – While these remain the minimum famous decision, evaporative condensers can be utilized inside or outside of a building and under normal conditions, work at a low gathering temperature. Ordinarily these are utilized as a part of vast business ventilating units. Albeit viable, they are not really the most productive.Preceding starting your introduce, ensure you pick a condenser that will give you the most proficient utilize.

Chapter-2 LITERATURE REVIEW

1. Although there are a few strategies for the expectation of warmth move in helical curls, quite a bit of those connections are restricted to a particular liquid, mass speeds, and warmth fluxes ranges. There is a need to anticipate the bubbling warmth exchange precisely for better plan of helical curl warm exchangers.

2.Dry out in helical curls was found to have bring down surface to liquid temperature distinction at the basic warmth flux contrasted with straight tubes along these lines diminishing the crumbling in warm execution contrasted with straight tube at dryout conditions.

3. Although there were helical loops tried for smaller than expected frameworks, for example, the work done by Wu et al. (2010) and Kim (2000) the execution, tests were done utilizing R22 and no information was accounted for such frameworks utilizing R134a. As the warm properties of R134a (Prl= 3.472 at 15°C immersion temperature) don't contrast fundamentally from those of R22(Prl= 2.443 at 15°C immersion temperature), it is normal that the patterns of the outcomes won't be subjectively unique in relation to those delivered with R22. In any case, exploring the warmth exchange execution of R134a in little distance across tubes helical curls is important to give quantitative outcomes that can be utilized as a part of the plan of little scale evaporators notwithstanding underscoring the patterns of stream bubbling in little measurement tubes.

4. Torii (2007) measured the convective warmth exchange of nano precious stone particles in water stream in 1m long, 4 mm distance across tube at three volume divisions 0.1%, 0.4%, 1% with Reynolds number went from 3000 to 6000. The particles were accepted round in light of the TEM picture (Transmission Electron Microscope). Noteworthy improvement in respect to water particularly at high Reynolds number and volume portions were watched. The upgrade in warm exchange (up to 25 %) was higher than the improvement in warm conductivity (up to 15% at 5% volume division) and was clarified by a few variables incorporating the diminishment in limit layer thickness, suspension and relocation of particles.

5. Recently, numerous specialists have tentatively explored the impact of nanofluids in upgrading the warmth move coefficient in straight tubes in laminar stream, for example, Heris et al. (2006) utilizing alumina (Al2O3), copper oxide (CuO) and copper (Cu) nanoparticles scattered in water, Murshed et al. (2007) utilizing titanium dioxide (TiO2) scattered in water, and Rea et al. (2009) utilizing Al2O3 and zirconia in the laminar stream administration. Heris et al.(2006) detailed upgrade of 35% contrasted with immaculate water stream at a similar test conditions utilizing Al2O3, CuO, and Cu particles. Murshed et al. (2007) found an improvement by up to 14% utilizing TiO2 with volume parts between 0.2% to 0.8%. Rea et al. (2009) revealed up to 27% upgrade utilizing Al2O3 up to 6% volume portions.

Chapter-3DESIGN ANDMODELLING:

CATIA offers a solution to shape design, styling, surfacing workflow and visualization to create, modify, and validate complex innovative shapes from industrial design to Class-A surfacing with the ICEM surfacing technologies. CATIA supports multiple stages of product design whether started from scratch or from 2D sketches. CATIA is able to read and produce STEP format files for reverse engineering and surface reuse

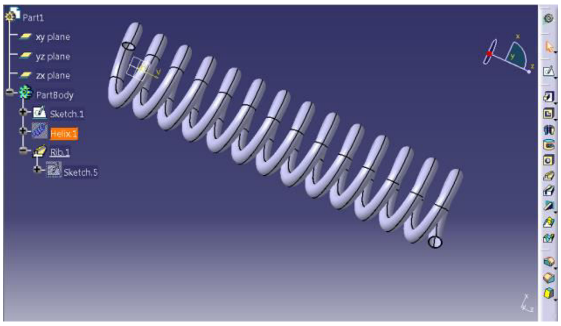


Fig1.2: Sketcher of existinghelical condenser coil

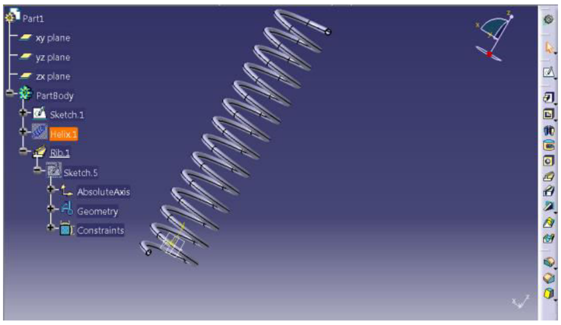


Fig1.3: Sketcher of modifiedhelical condenser coil

Chapter-4 ANALYSIS :

ANSYS is general-purpose finite element analysis software, which enables engineers to perform the following tasks:

1. Build computer models or transfer CAD model of structures, products, components or systems
2. Apply operating loads or other design performance conditions.
3. Study the physical responses such as stress levels, temperatures distributions or the impact of electromagnetic fields.
4. Optimize a design early in the development process to reduce production costs.

5. A typical ANSYS analysis has three distinct steps.

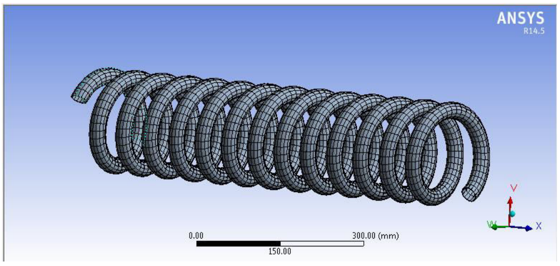
6. Pre Processor (Build the Model).

ANALYSIS OF RESULTS:

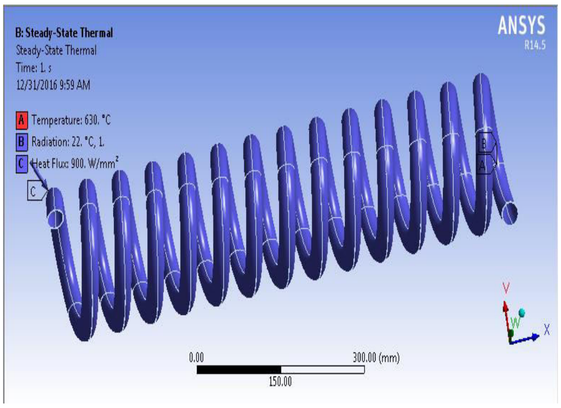
In this chapter, the results obtained for the analysis of enivarmental chamber system for the original profile and dynamic structural analysis are discussed. And also explained the graphs plotted by comparing those results.

Existing helical condenser coil:

Mesh



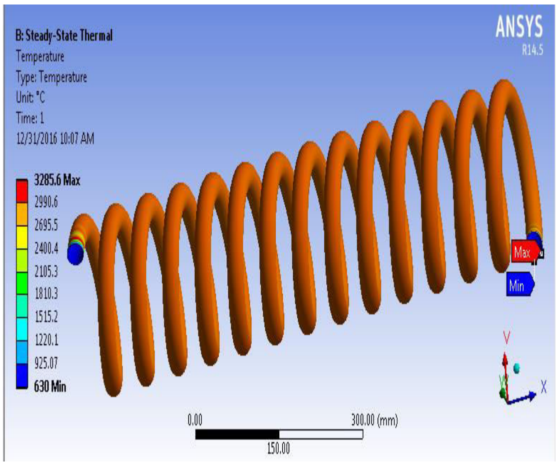
Loads


B: Steady-State Thermal
Steady-State Thermal
Time: 1. s
12/31/2016 9:59 AM
A Temperature: 630. °C
B Radiation: 22. °C, 1.
C Heat Flux: 900. W/mm²

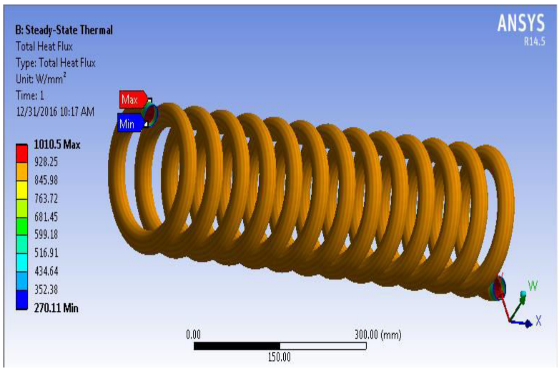
Copper

Thermal Conductivity	0.4 W mm^-1 C^-1
Density	8.933e-006 kg mm^-3
Specific Heat	3.85e+005 mJ kg^-1 C^-1

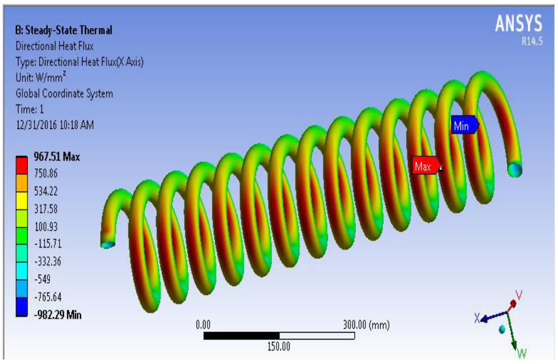
Temperature:



Total heat flux:



Directional heat flux:



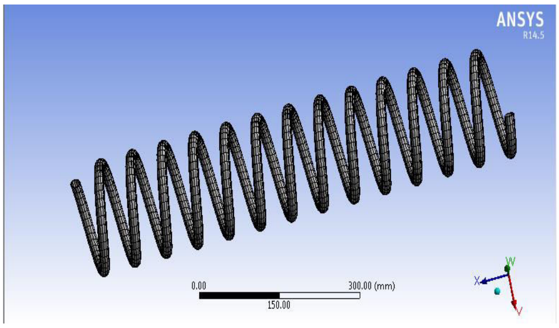
Object Name	*Temperature*	*Total Heat Flux*	*Directional Heat Flux*	*Thermal Error*
Minimum	*630. °C*	*270.11 W/mm²*	*-982.29 W/mm²*	*4.4012e+005*
Maximum	*3285.6 °C*	*1010.5 W/mm²*	*967.51 W/mm²*	*1.1662e+009*

Modified helical condenser coil:

Copper

Thermal Conductivity	0.4 W mm^-1 C^-1
Density	8.933e-006 kg mm^-3
Specific Heat	3.85e+005 mJ kg^-1 C^-1

- **Mesh:**



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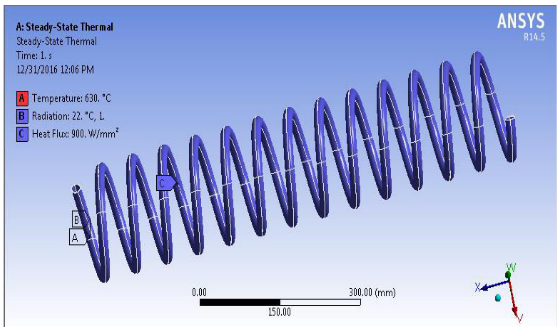
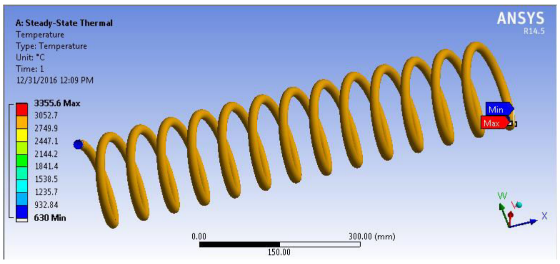
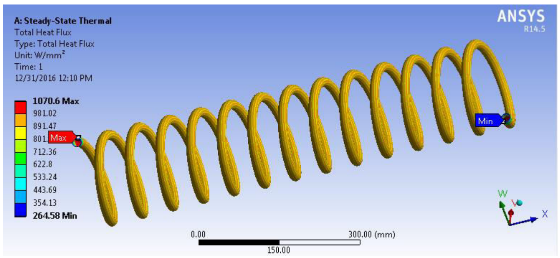


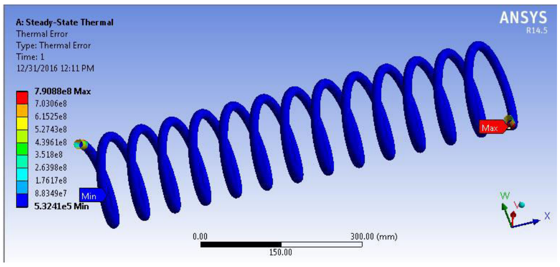
Temperature:



Total heat flux:



Thermal Error:



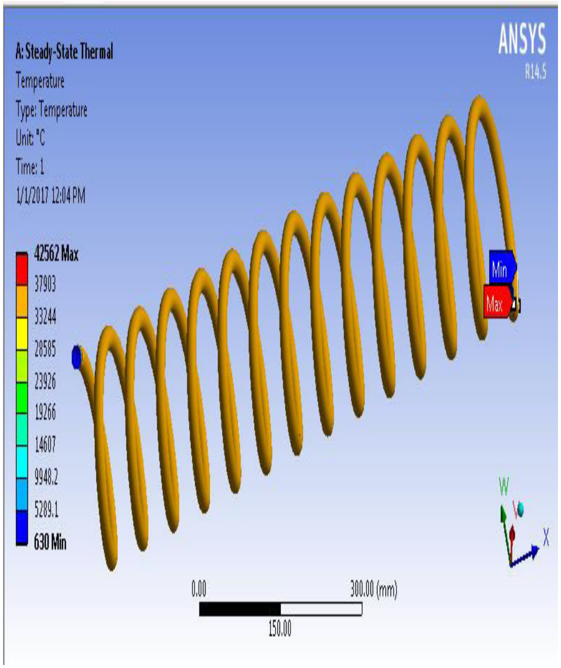
Object Name	*Temperature*	*Total Heat Flux*	*Directional Heat Flux*	*Thermal Error*
Minimum	630. °C	264.58 W/mm²	-1030.5 W/mm²	5.3241e+005
Maximum	3355.6 °C	1070.6 W/mm²	1014. W/mm²	7.9088e+008

So observing the above results of ac condenser coils change the diameters of coils above result will be occurred, condenser coil 1 is comparing with condenser coil 2 is more temperature withstand limit and more heat transfer rate, comparing condenser coil 1 with condenser coil 2 thermal errors is less in condenser coil 2. So condenser coil 2 is more efficiency comparing with condenser coil 1 So condenser coil 2 is more suitable for more efficiency hvac systems. So these are analysis with three different suitable property materials and finalize which one is given better efficiency

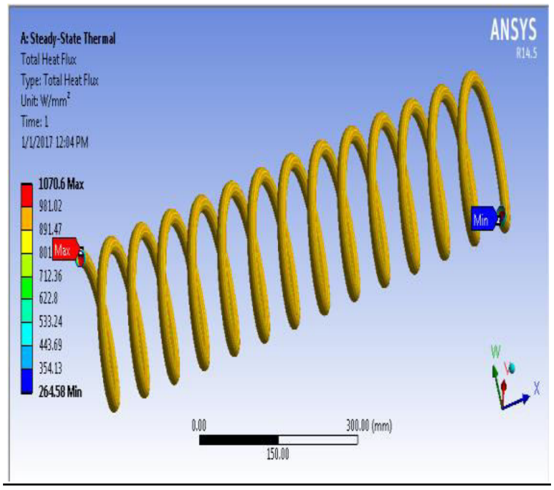
- **<u>Material Data</u>**
    - **Magnesium alloy:**

Density	1800 kg m^-3
Coefficient of Thermal Expansion	25.6 C^-1
Specific Heat	373 J kg^-1 C^-1
Thermal Conductivity	26 W m^-1 C^-1

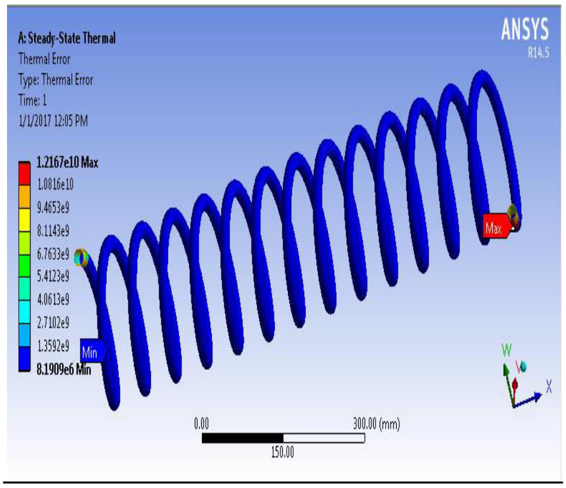
Temperature:



Total heat flux:



Thermal Error:

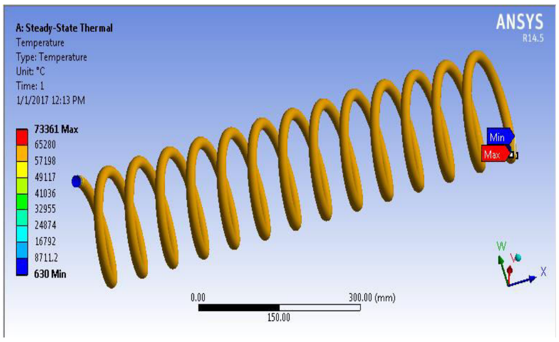


Object Name	*Temperature*	*Total Heat Flux*	*Directional Heat Flux*	*Thermal Error*
Minimum	*630. °C*	*264.58 W/mm^2*	*-1030.5 W/mm^2*	*5.3241e+005*
Maximum	42562 °C	1070.6 W/mm^{22}	1014. W/mm^2	1.2167e+010

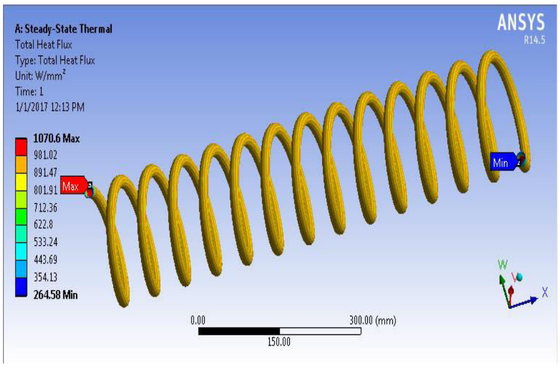
Aluminium Alloy Al99 :

Density	2.7e-006 kg mm^-3
Coefficient of Thermal Expansion	22 C^-1
Specific Heat	9.e+005 mJ kg^-1 C^-1
Thermal Conductivity	1.499e-002 W mm^-1 C^-1

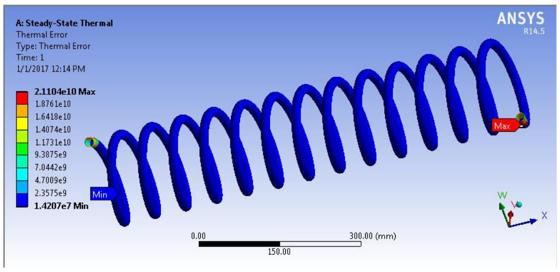
Temperature:



Total heat flux:



Thermal Error:

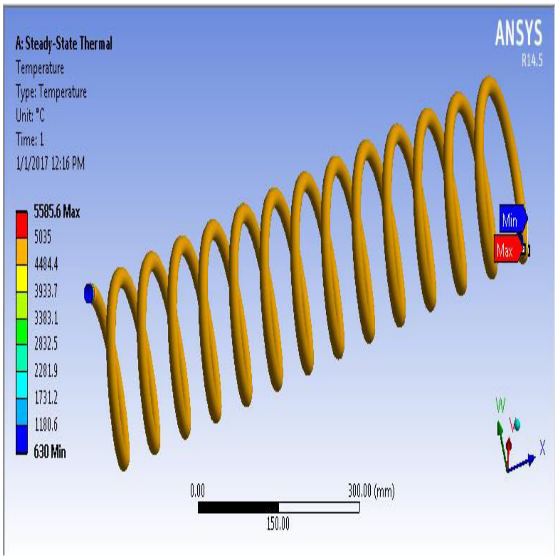


Object Name	Temperature	Total Heat Flux	Thermal Error	Directional Heat Flux
Minimum	40. °C	1.9905e-012 W/m^2	4.8931e-033	-7.0698e+005 W/m^2
Maximum	73361 °C	1070.6 W/mm^2	1014. W/mm^2	2.1104e+010

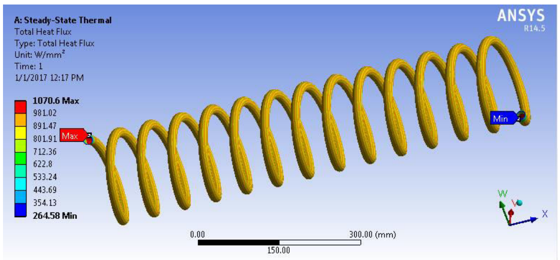
g al cu 4img 204:

Density	7.81e-006 kg mm^-3
Coefficient of Thermal Expansion	17.1 C^-1
Specific Heat	1.19e+005 mJ kg^-1 C^-1
Thermal Conductivity	0.22 W mm^-1 C^-1

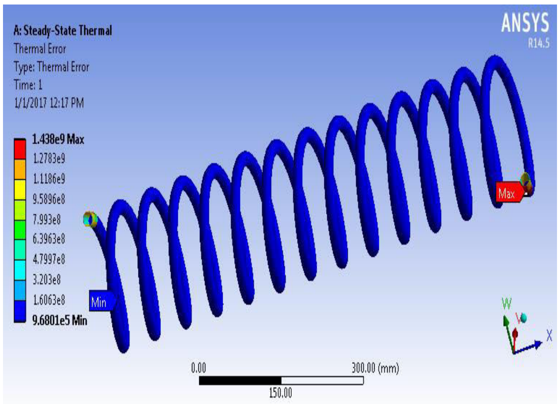
Temperature:



Total heat flux:



Thermal Error:



Object Name	Temperature	Total Heat Flux	Thermal Error	Directional Heat Flux
Minimum	40. °C	2.9213e-011 W/m^2	7.1813e-032	-9.9316e+006 W/m^2
Maximum	5585.6 °C	1070.6 W/mm^2	1014. W/mm^2	1.438e+009

CFD ANALYSIS:

CFD analysis is performed in fluent environment by applying the properties of different fluids to determine pressures, heat transfer coefficients and heat transfer rates.

FLUID PROPERTIES

R134A

Density: 1376.7 Kg/m^3

Cp: 1.281 KJ/Kg-K

Thermal conductivity: 103.9 W/m-K

Viscosity: 384.2 Pa's

R407C

Density: 1380.7 Kg/m^3

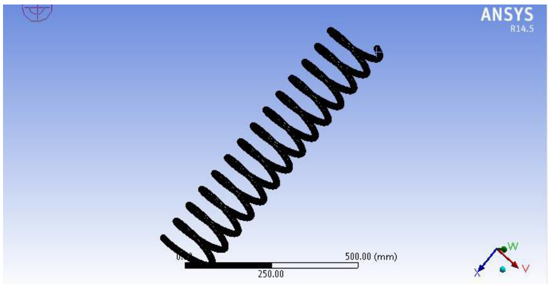
Cp: 0.787 KJ/Kg-K

Thermal conductivity: 127.9W/m-K

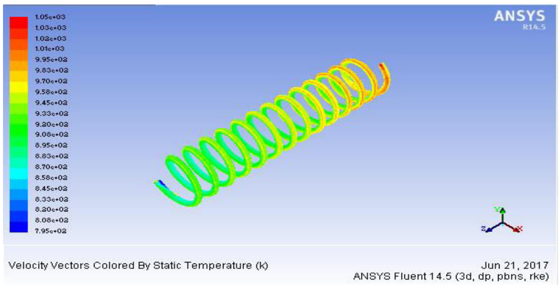
Viscosity: 384.6 Pa's

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

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



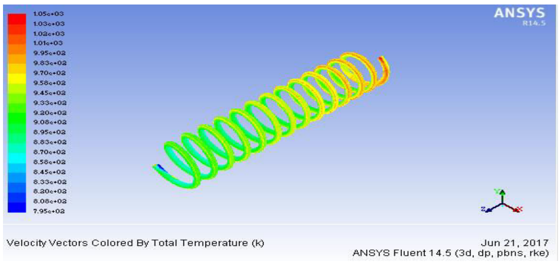
R134A



Velocity Vectors Colored By Static Temperature (k)

Jun 21, 2017
ANSYS Fluent 14.5 (3d, dp, pbns, rke)

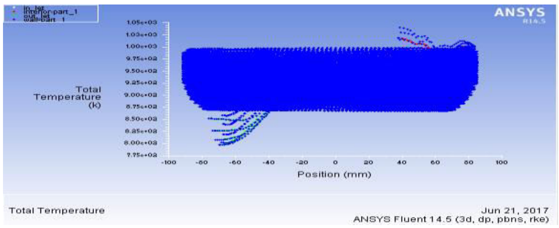
Fig 3.1velocity vectors colored by static temperature



Velocity Vectors Colored By Total Temperature (k)

Jun 21, 2017
ANSYS Fluent 14.5 (3d, dp, pbns, rke)

Fig 3.2velocity vectors colored by total temperature

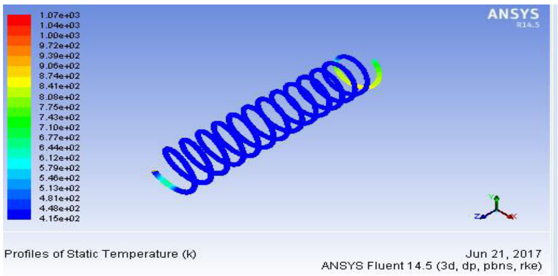


Total Temperature

Jun 21, 2017
ANSYS Fluent 14.5 (3d, dp, pbns, rke)

Fig 3.3 Graph of total temperature

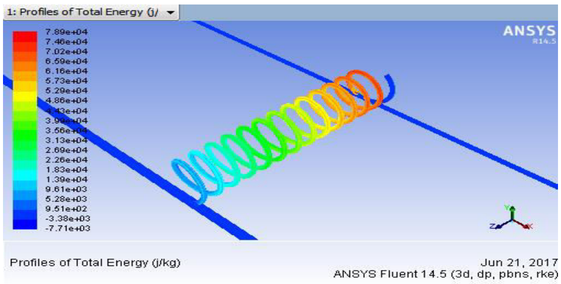
R407c



Profiles of Static Temperature (k)

Jun 21, 2017
ANSYS Fluent 14.5 (3d, dp, pbns, rke)

Fig 3.4 Profiles of static temperature



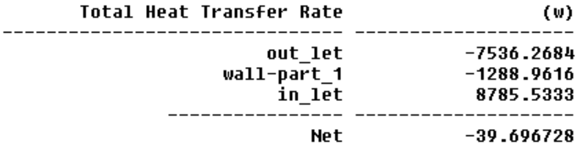
Profiles of Total Energy (j/kg)

Jun 21, 2017
ANSYS Fluent 14.5 (3d, dp, pbns, rke)

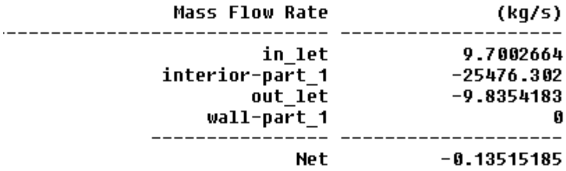
Cfd result:

Minimum Absolute Pressure	1
Maximum Absolute Pressure	5e+10
Minimum Temperature	1

Maximum Temperature 5000
Minimum Turb. Kinetic Energy 1e-14
Minimum Turb. Dissipation Rate 1e-20
Maximum Turb. Viscosity Ratio 100000



```
        Total Heat Transfer Rate                         (w)
-------------------------------- --------------------
                         out_let          -7536.2684
                     wall-part_1          -1288.9616
                          in_let           8785.5333
                ---------------- --------------------
                             Net          -39.696728
```



```
                 Mass Flow Rate                     (kg/s)
-------------------------------- --------------------
                         in_let            9.7002664
               interior-part_1            -25476.302
                        out_let           -9.8354183
                    wall-part_1                    0
                ---------------- --------------------
                            Net          -0.13515185
```

Conclusion:

- ➢ So over three material outcomes watching I infer that
- ➢ Aluminum Alloy Al99 happened more temperature 73361 °C contrasted and other two materials
- ➢ Total Heat Flux is same esteem got in every one of the three materials
- ➢ Thermal blunder is less in G Al Cu 4IMG 204 material contrasted and other two materials
- ➢ Finally Aluminum Alloy Al99 material is more appropriate for condenser curl due to more temperature esteem contrasting and left copper material
- ➢ By looking at the CFD examination comes about, the warmth exchange rate, warm exchange coefficient, weight, speed and mass stream rate are expanding by expanding the warm proficiency rate.
- ➢ So it can be reasoned that expanding the warm productivity of helical curl gives better execution in cfd comes about.

References

- Agostini, B., Bontemps, A. (2005). Vertical flow boiling of refrigerant R134a in small channels. International Journal of Heat and Fluid Flow 26: 296-306.
- Akhavan-Behabadi, M. A., Aria, H., and Shemirani, F. M. (2009). Flow boiling heat transfer of HFC-134a inside helically coiled tubes. In Proceedings of InternationalConference on Applications and Design in Mechanical Engineering (ICADME),Malaysia.
- Akhavan-Behbadi, M.A., Hashemi, S.M.(2010).Pressure drop characteristics of nanofluid flow in horizontal coiled tube under constant heat flux. In: BiennialConference in Engineering Systems Design and Analysis, ASME, Turkey.
- Balakrishnan, R., Santhappan, J. S. and Dhasan, M. L. (2009). Heat transfer correlation for a refrigerant mixture in a vertical helical coil evaporator. Thermal Science 13(4), 197-206.
- Bradshaw, C., Groll, E.A.,Garimella, S.V.(2011). A comprehensive model of a miniature-scale linear compressor for electronics cooling. International Journal ofRefrigeration (2011), 34:63-73.
- Bergles, A. E. (2002). ExHFT for fourth generation heat transfer technology. Experimental

Thermal and Fluid Science, 26: 335–344.

- Bejan, A., and Kraus, A. (2003). Heat Transfer Handbook. J. Wiley.
- Bell, K. J. and Owhadi, A.(1969) . Local heat transfer measurements during forced convection boiling in a helically coiled tube. Proceedings of the Institution ofMechanical Engineers, 184(3C): 52-58.
- Bi, Q., Chen, T., Tian, Y., Chen, X. (1997). Experimental Study on steam-water two-phase flow frictional pressure drops in helical coils. Nuclear Science andTechniques 8(3): 149-153.
- Bianco, V., Manca,O., and Nardini, S. (2011). Numerical investigation on nanofluids turbulent convection heat transfer inside a circular tube. International Journal ofThermal Sciences 50: 341-349.
- Cary,V.P. (1992).Liquid-vapor phase-change phenomena: an introduction to the thermophysics of vaporization and condensation processes in heat transfer equipment. Hemisphere publisher.