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Improving the Performance of the Evaporator by Using Nano Refrigerant, De Ionized Water and Double Pipe Heat Exchanger. Analysis Carried Out by Using CFD

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ABSTRACT:

This is deals with performance of design and analysis of double pipe heat exchangers by using nano refrigerant in refrigeration system and improve the efficiency of refrigeration system and decrease work load on compressor by using the mixture of R134a and Al_2o_3 as the nano refrigerant by using in double pipe heat exchanger. In this investigation, we consider pressure, volume fraction and flow rate as parameters. In nano refrigerant mixture 99% refrigerant and 1% Al_2o_3 considered. In single pipe R134a is as refrigerant at intial temp of refrigerant is 275k and pressure 0.4bar and water intial temp 300k another process using nano refrigerant at the pressure rate 0.4 bar and intial temp is 275k. In double pipe heat exchangers process using R134a is as refrigerant flows in inner pipe and distilled ionized water flows outer pipe another process we use nano refrigerant at intial temp of distilled water is 300k at refrigerant temp is 275k and water temp is 300k.

The distilled ionized water flow rate is 0.01%. In single pipe refrigerant temp varies from 275 k to 298 k and the water temp drops from 300 to293. In single pipe by using nano refrigerant, the refrigerant temp varies from 275 k to 300k and water temp drops from 300 to 292 k. In double pipe heat exchangers process refrigerant temp varies from 275k to 292k.temp of water to 292k.Distilled water temp drops from 300k to 295k. Using nano refrigerant the refrigerant temp drops from 275k to 292k.water temp drops from 300 to 287.distilled water temp drops from 300k to 293k. Then single pipe heat exchanger by using refrigerant, the water temp7^0C decrease from intial temp at 27^0C. adding1% nano particle with R134a the water tem 9^0C decrease from intial 27^0 C. In double pipe by using R134a the water temp decreases from 10^0C to intial temp 27^0C by using de ionized water on outer pipe, after adding Al_2o_3 nano particle with refrigerant the water temp drops to 13^0C from intial temp27^0C so that in this experiment double pipe evaporator by using nano refrigerant is easily cool down the water temp compare than others and deionized water as cooling agent.

KEYWORDS:
R134a refrigerant, Al_20_3 nanofluid, distilled ionized water, double pipe heat exchanger, temperature difference.

1.1 INTRODUCTION:

Heat exchangers are a device that exchange the heat between two fluids of different temperatures that are separated by a solid wall. Transfer of heat happens by three principle means: radiation, conduction and convection.

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In the use of heat exchangers radiation does take place. However, in comparison to conduction and convection, radiation does not play a major role. The double-pipe heat exchanger is one of the simplest types of heat exchangers. It is called a double-pipe exchanger because one fluid flows inside a pipe and the other fluid flows out side the pipe . in general refrigeration process refrigerant flows through pipe absorbe the heat energy from water that temperature of refrigerant flows through compressor then compressor work load increasesand gives temperature and pressure. So in this proceses Al203 nano fluid is adding to the refrigerant then increases efficiency and decreases workload on compressor .

Nano particles are very small in size, usually < 100 nm .Nanofluids have unique features different from convectional solid- liquid mixtures in which mm (or) µm sized particles of metals and non metals are dispersed. Due to their excellent characteristics, nanofluids find wide application inenhancing heat transfer characteristics namely extreme stability, high thermal conductivity. Heat transfer surface area increases due to Brownian motion and inter particle forces so that increased thermal conductivity. Distilled ionize water pipe consists out side of refrigerant it uses to gives the temperature to the nano refrigerant .nano refrigerant having some amount of temperature and absorb temperatures from normal water and distilled water then absorb high temperature then to decreases the workload on compressor and increases efficiency of the system.

1.2 LITERATURE SURVEY

Xiaohao Wei et presented The effect of reactant molar concentration and nano fluid temperature on thermal conductivity. Nano particles shape is (spherical to octahedral)variable by adjusting some synthesis parameters such that enhance thermal conductivity up to 24%. Cu2O nano fluids can be synthesized by using the chemical solution method.

Pooyan Razi et al assessed Nano fluids with different particle weight concentration passing through theflat end copper tubes and heated by an electrical heating coil and created fully developed flow. Study the effect of different parameters on heat transfer coefficient and pressure drop flow is studied. The results show down a maximum increase of 16.8% in heat transfer coefficient for a range of Reynolds numbers between 10 to 100 is obtained for nano fluid flow with 2% wt. concentration inside the round tube, while, the increases of 20.5% and26.4 are obtained for this fluid flow inside the flattened tubes with internal heights of 8.3 and 6.3 mm at nearly the same Reynolds numbers range, respectively.

M. Chandrasekhar et al implemented nano fluid Prepared by microwave method assisted chemical precipitation method. Different volume concentrations at room temperature were used for investigation conclude that the viscosity increase is substantially higher than the increase in the thermal conductivity. Patricia E [12]studied The effect of particle diffusion in a temperature field on the aggregation and transport and the predicted thermal conductivity and viscosity enhancements are compared to determine the favor ability of aggregation nano fluid.

Specification of nano particles

Chemical name: Aluminum Oxide
Purity: 99%
Appearance: white
Odor: Alcoholic
Average particle size: 30-50nm
Density: 1232.24 kg/m^3
Specific heat: 1219.604 J/kg K
Thermal Conductivity: 0.481576 W/K
Viscosity: 0.00202 pa-s

Specification of R134 a refrigerant

Density: 1206 kg/m3
Specific heat: 1440 J/kg K
Thermal Conductivity: 0.0824 W/m K
Viscosity: 0.00202 pa-s

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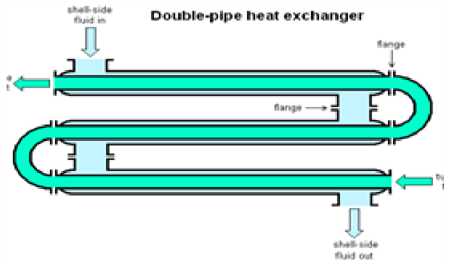
1.1 Heat Exchanger

A heat exchanger is a device that allows heat from a fluid (a liquid or a gas) to pass to a second fluid (another liquid or gas) without the two fluids having to mix together or come into direct contact. Exchanger is a device designed to efficiently transfer or "exchange" heat from one matter to another. Heat transfer devices are provided in many refrigeration systems to exchange energy between the cool gaseous refrigerant leaving the evaporator and warm liquid refrigerant exiting the condenser

1.2 Refrigeration:

Refrigeration is a process of transferring thermal energy from one position to another in controlled conditions. Refrigeration or cooling process, is the removal of unwanted heat from a selected object, substance, or cooling process, is the removal of unwanted heat from a selected object, substance, or, space and its transfer to another object, substance, or space. Refrigeration is a process of removing heat from a low-temperature reservoir and transferring it to a high-temperature reservoir.



1.3. COMPONENTS OF VAPOUR COMPRESSION REFRIGERATION SYSTEM

a) compressor, b)condenser c) evaporator

d) Expansion valve

1.4.Compressor:

A refrigerant compressor is a machine used to compress the vapor refrigerant from the evaporator and to raise its pressure. so that the corresponding saturation temperature is higher than that of the cooling medium. Compressor gives motive force to the whole refrigeration system since the compression of refrigerant requires some work to be done on it, therefore a compressor must be driven by some mover (i.e. motor).

1.5 CLASSIFICATION OF COMPRESSORS

1 .According to method of compression Reciprocating compressor Rotary compressor, and Centrifugal compressors

2. According to the no. of working strokes

3.Single acting compressor, and Double acting compressor

Vapour Compression Refrigeration Assemble

Evaporator

1.8 Types of evaporators used today

Natural/forced circulation evaporaton Falling film evaporator and Rising film (Long Tube Vertical) evaporator. Multiple-effective evaporators and Vapour compression evaporator.

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1.9 Expansion valve

The expansion valve removes pressure from the liquid refrigerant to allow expansion or change of state from a liquid to a vapor in the evaporator.

2.0.Refrigerant:

Chemical refrigerants are assigned an R number which is determined systematically according to molecular structure. Common refrigerants are frequently referred to as Freon

Some examples are given and their fields of application

CFC = Chlorofluorocarbons.
HCFC = Hydro Chlorofluorocarbons.
HFC = Hydro Fluor Carbons.
FC = Fluor Carbons.
HC = Hydro Carbons.

2.1 Most common refrigerant

R-134a Refrigerant

It is used in many air conditioning and refrigeration systems globally. It is a hydro-fluorocarbon (HFC) that does not contribute to ozone depletion; also the first non-ozone-depleting fluorocarbon refrigerant to be commercialized.

Most common applications for R134a

R134a is not only used for air conditioning systems on cars. Their most common uses include:
a) Commercial refrigeration b) Industrial refrigeration c) Domestic refrigeration d)Transport refrigeration

2.2 .Nan particle

Nano particles are particles between 1 and 100 nanometers (nm) in size with a surrounding interfacial layer. In Nano fluid Al2o3 used to show a significant increment with the increase of volume fractions. substantial enhance of thermal conductivities properties like thermal conductivities, viscosity, and heat transfer characteristics improve the system efficiency.

Nano fluid:

Nano fluid is a fluid containing nanometer-sized particles, called nano particles . These fluids 1are engineered colloidal suspensions of nano particles in a base fluid.

Applications of nano fluids Heat Transfer Applications:

a. Industrial Cooling Applications b . Smart fluid
c. Nuclear reactor

2.3 Nano particle materials may include:

Oxide ceramic – Al2O3, CU Nitrides – ALN, SIN Metals – Al, Cu Layered – Al + Al2O3, Cu + C Water, Ethylene- or tri-ethylene-glycols and other coolants

2.4 Ionized water

Ionized water is nothing but H2O split into 2H+ + OH- ions. Water molecules exhibit a very slight tendency to dissociate ("ionize") into hydrogen ions and hydroxide ions: H20 ; H+ + OH-

Properties:

Thermal conductivity, Density , Surface tension

3.4 CATIA

(Computer Aided Three-dimensional Interactive Application) is a multi-platform CAD/CAM/CAE commercial software suite developed by the French company Dassault. Written in the C++ programming language, CATIA is the cornerstone of the Dassault Systems product lifecycle management software suite. CATIA competes in the high end CAD/CAM/CAE market with Creo Elements/Pro and NX (Unigraphics).CATIA (Computer Aided Three-Dimensional Interactive Application) started as an in-house development in 1977 by French aircraft manufacturer Avions Marcel Dassault, at that time customer of the CAD/CAM CAD software to develop Dassault's Mirage Fighter jet. It was later adopted in the aerospace, automotive, shipbuilding, and other industries.

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3.5 MODELLING OF INLINE FLAT TUBES

To create the heat exchanger CATIA V5-6R 2016 software is used. Here the heat exchanger mainly consists of four parts, they are, one is tubes, water in tube, cabin, thermo coil and outer casing.. All these are individual components. Rib command is used to to create the helical pipe, here coil outer dia 12mm is , inner dia 10 mm, pitch of coil 20 mm and number of pipes are 12. as shown in fig.1

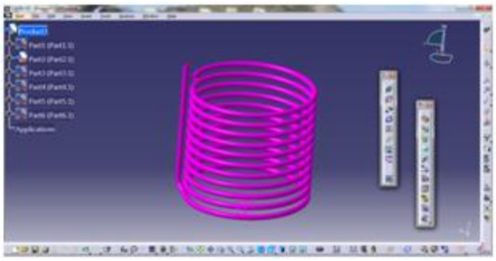
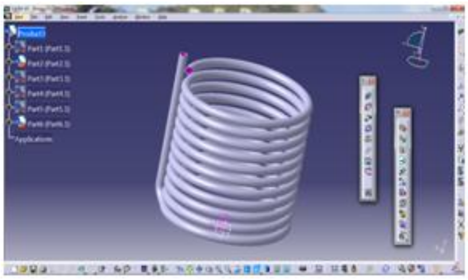


Fig: evaporator coil model in CATIA

Rib command is used to to create the helical pipe, here coil outer dia 15 mm is , inner dia 14.5mm, pitch of coil 20 mm and number of pipes are 12. as shown in fig.5.4.



Evaporator coil in outer pipe

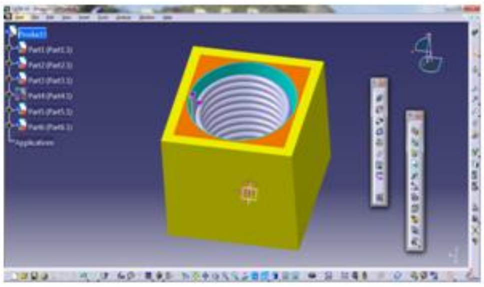


Fig: final Geometry of assembly

Pad command is used to create the outer case. which is placed outer side of coil arrangement. which is arranged as experimental rig. In this ANSYS, different types are elements are used that are depend on the selection of object shape project concept. These elements are given below

Truss or Link element
1.Frame or beam element
2.Plate or shell element
3.3D or solid element
4.Tube or pipe element

From the above elements, we have to analyze different engineering related problems.

That are

A. Static condition
B. Dynamic condition
1. Natural frequency analysis
2. Harmonic analysis
3 Fatiuge analysis
4. Creep analysis
5. Buckling analysis
6. Impact analysis
7. Contact analysis
8. Transient analysi
9.Thermal related analysis
10. Fluent analysis
11. Combinational analysis

ANSYS workbench has simple steps to solve any type of engineering related problems. And it is easily understandable for a common man. We can perform any analysis mentioned above by using ANSYS software. We have to maintain a procedure; they are

1.Preferences

A. Structural analysis
B. Thermal analysis
C. Fluent analysis

2.Preprocessor

A. Element type
B. Section and real const
C. Material properties
D. Modeling and geometry creation
E. Finite element modeling

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3.Solution
A. Boundary condition
B. Loading
C. Solve

4. Postprocessor
A. Nodal solution
B. Element solutions
C. Plot representation
D. Graph representation.

3.6 CFD ANALYSIS
CFD is one of the branches of fluid mechanics that uses numerical methods and algorithms to solve and analyze problems that involve fluid flows. Computers are used to perform the millions of calculations required to simulate the interaction of fluids and gases with the complex surfaces used in engineering. However, even with simplified equations and high speed supercomputers, only approximate solutions can be achieved in many cases

3.7 Discretization Methods in CFD
1.Finite difference method (FDM)
2.Finite volume method (FVM)
3.Finite element method (FEM)

3.8 CFD Analysis Procedure
For a given problem, you will need to Select appropriate physical models Turbulence, combustion, multiphase, etc

Define material properties
Fluid
Solid
Mixture
Prescribe operating conditions
Prescribe boundary conditions at all boundary zones

6.1.3 CFD Code Working
CFD codes are structured around the numerical algorithms that can be tackle fluid problems. In order to provide easy access to their solving power all commercial CFD packages include sophisticated user interfaces input problem parameters and to examine the results. Hence all codes contain three main element

1. **Pre-Processing**
2. **Solver**
3. **Post-Processing**

3.8 CFD ANALYSIS OF HEAT EXCHANGER SIMULATION RESULTS FOR INLINE ARRANGEMENT
Computational fluid dynamics (CFD) study of the system starts with the construction of desired geometry and mesh for modeling the dominion. Generally, geometry is simplified for the CFD studies. Meshing is the discretization of the domain into small volumes where the equations are solved by the help of iterative methods. Modeling starts with the describing of the boundary and initial conditions for the dominion and leads to modeling of the entire system. Finally, it is followed by the analysis of the results, conclusions and discussions.

3.9 Geometry:
Heat exchanger is built in the ANSYS workbench design module. It is a counter-flow heat exchanger. First, the fluid flow (fluent) module from the workbench is selected.

4.1 Merging
After import the model into ANSYS from CATIA, it will show the model as 3 parts . For merge operation, all the 4 parts are selected using control and merged as 1 part. At the end it will show as 1 part and 4 bodies. The 4 bodies within 1 part are named as follows:

Part number	Part name	State of part
1	Pipes and Insulation	Solid
2	Water	Fluid
3	Refrigerant	Fluid
4	Casing	Solid

Table 6.1: Naming of various parts of the body with state type.

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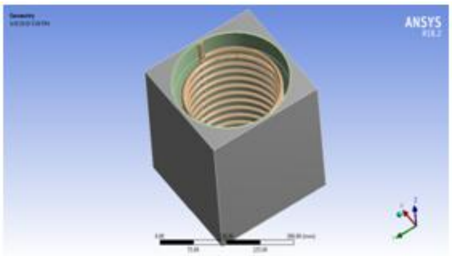
Save the project at this point and close the window. Refresh and update the project on the

4.2 Mesh:

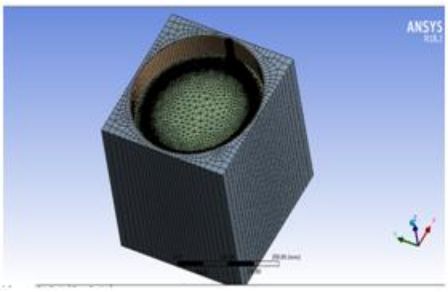
Initially a relatively coarser mesh is generated. This mesh contains mixed cells (Tetraand Hexahedral cells) having both triangular and quadrilateral faces at the boundaries. Care is taken to use structured hexahedral cells as much as possible. It is meant to reduce numerical diffusion as much as possible by structuring the mesh in a well manner, particularly near the wall region. Later on, a fine mesh is generated. For this fine mesh, the edges and regions of high temperature and pressure gradients are finelymeshed. the mesh details view gave us the following

Information: Relevance centre: fine meshing
Smoothing: high
Size:0.2mm
Nodes:105558
Elements:490938

IMPORTED MODEL

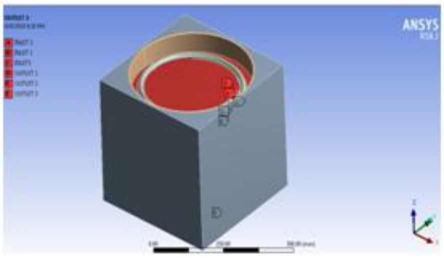


MESHING OF GEOMETRY



All the parts (of assembly of evaporator) are named with different names to identify the components and each part is mentioned as either solid domain or fluid domain.

The fig.5.10 shows the fine mesh. The hexahedron elements are used to generating mesh. Meshing has 490938 elements and 105558 nodes



Name: selectionfor evaporator assembly.

4.3 Named Selection

The different surfaces of the solid are named as per required inlets and outlets for inner and outer fluids. The outer wall is named as insulation surface.
Save project again at this point and close the window. Refresh and update project on the workbench. Now open the setup. The ANSYS Fluent Launcher will open in a window. Set dimension as 3D, option as Double Precision, processing as Serial type and hit OK. The Fluent window will open

4.4 Solution: 4.4.1 Problem Setup

The mesh is checked and quality is obtained. The analysis type is changed to Pressure Based type. The velocity formulation is changed to absolute and time to steady state. Gravity is defined as y = -9.81 m/s2

4.4.3Materials

The create/edit option is clicked to add water-liquid and copper to the list of fluid and solid respectively from the fluent database.

THERMODYNAMIC PROPERTIES OF INSULATION

S.NO	Properties	Polyurethane
1	Density(ρ)(Kg/m^3)	64
2	Thermal conductivity (K) (W/mk)	0.29
3	(C_p)(J/Kg k)	1.5

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THERMODYNAMIC PROPERTIES OF ALUMINUM

1	Density(ρ)(Kg/m^3)	1232
2	Thermal conductivity(K)(W/mk)	0.4815
3	(C_p)(J/Kg k)	1219

THERMODYNAMIC PROPERTIES OF R134a

S.NO	Properties	Steel core
1	Density(ρ)(Kg/m^3)	1206
2	Thermal conductivity(K)(W/mk)	0.0824
3	(C_p)(J/Kg k)	1440

4.4.4 Cell zone conditions:

The parts are assigned as water and copper as per fluid/solid parts.

4.4.5 Boundary Conditions

Boundary conditions are used according to the need of the model. The inlet and outlet conditions are defined as velocity inlet and pressure outlet. As this is a counter-flow with two tubes so there are two inlets and two outlets. The walls are separately specified with respective boundary conditions. No slip condition is considered for each wall. Except the tube walls each wall is set to zero heat flux condition. The details about all boundary conditions can be seen in the table 3 as given below. evaporator inlet temp=2^{0}c water temp=27^{0}c evaporator inlet pressure=0.4 bar.

4.5 Results of fluent analysis

It is a turbulent flow mixed heat exchanger. Initially the fluid is passing through the tubes with a viscosity of 0.00202 m/s and at a temperature of 2^{o}C. The water temperature of 27^{o}C flowing over the tube surface. Apply the fluid flow of pressure 0.4 bar. The heat is heat is transferred from the water to the tube surface by convection and then from the tube the heat is transferred parallel from the parallel pipes by conduction and convection

Single pipe refrigerant results

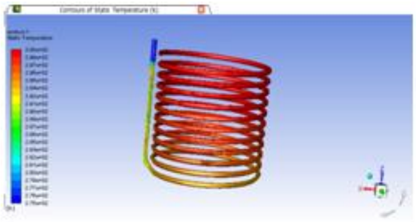
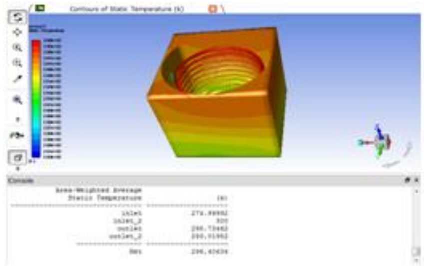


Fig: Temp distribution of evaporator coil



Temperature distribution of evaporator assemble

Single pipe nano refrigerant results

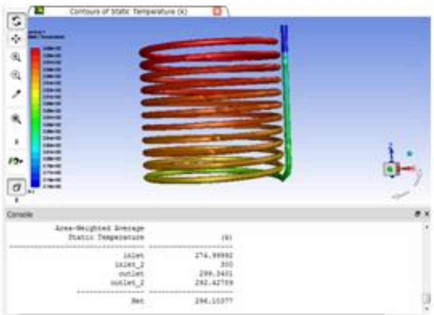


Fig: Temp distribution of evaporator coil.

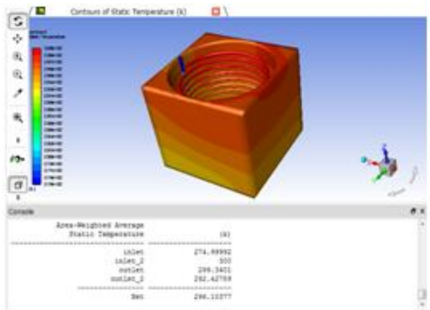


Fig: Temp distribution of evaporator assembly.

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Double pipe with refrigerant results:

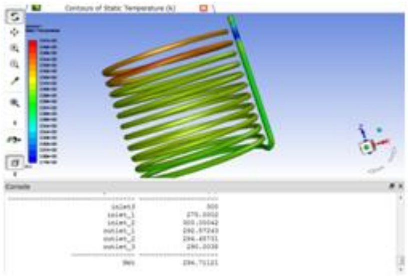

Fig: Temp distribution of evaporator coil.

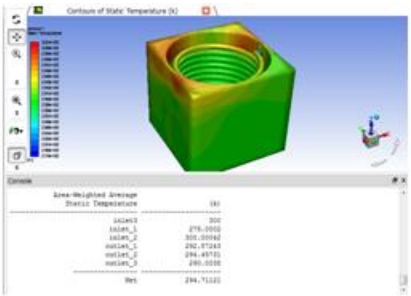

Fig: Temp distribution of evaporator assembly.

Double pipe with Nano refrigerant results:

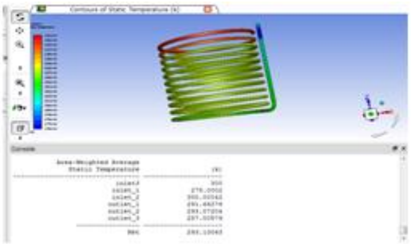

Fig: Temp distribution of evaporator coil.

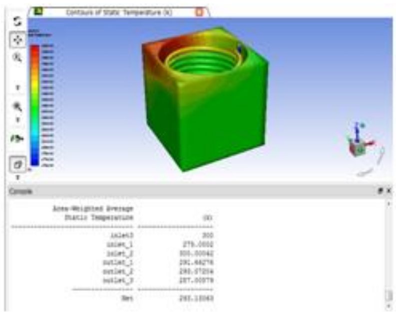

Fig: temp distribution of evaporator assemble

RESULTS

S.NO	NO. OF PIPES	TYPE OF REFRIGERANT	INLET TEMP OF WATER	INLET TEMP OF REFRIGERANT	OUTLET TEMP OF WATER	OUT LET TEMP OF REFRIGERANT
1	SINGLE PIPE	R134a	300	275	293	298
2	SINGLE PIPE	R134a+AL_2O_3	300	275	292	300

S.NO	NO. OF PIPES	TYPE OF REFRIGERANT	INLET TEMP OF WATER	INLET TEMP OF REFRIGERANT	OUTLET TEMP OF WATER	OUT LET TEMP OF REFRIGERANT	INLET OF DI-IONIZED WATER	OUTLET OF DI-IONIZED WATER
1	DOUBLE PIPE	R134a	300	275	290	292	300	295
2	DOUBLE PIPE	R134a+AL_2O_3	300	275	287	292	300	293

CONCLUSION:

From the above project work we concluded that, by using refrigerant 134a and nano refrigerant the water shows different temp values

1) for single pipe the by using refrigerant the water temp 7^0C decrease from intial temp at 27^0C

2) by adding 1%nanoparticle with R134a the water temp 9^0C decrease from intial 27^0C. For double pipe evaporator

3) In double pipe by using R134a the water temp decreases from 10^0Cto intial temp 27^0C. by using chilled water on outer pipe

4) After adding 1% Al_2o_3 nano particle to R134a the water temp 13^0C decreases from intial temperature 27^0C .from the above we concluded that in this pipe evaporater water temperature is easily cool down and it is given best results by using nano refrigerant and chilled water as cooling agent.

REFERENCE

[1] Abbas, M., et al, 2013, Efficient Air-condition unit by using nano-refrigerant, EURECA 2013, p. 87-88. Alawi, O., et al, 2015, Nano refrigerant effects in heat transfer performance and energy consumption: A review, International Communications in Heat Mass Transfer, 69 p. 76–83.

ISSN No: 2348-4845
International Journal & Magazine of Engineering, Technology, Management and Research
A Peer Reviewed Open Access International Journal

[2] Anoop, K., et al, 2014, Theology of mineral oil-SiO2 nanofluid at high pressure and high temperatures, International Journal of thermal sciences, 77 p. 108–115.

[3] Bartelt, K., et al, 2008, Flow-boiling of R134a/POE/CuO Nanofluid in horizontal tube, International Refrigeration and Air Conditioning Conference, Purdue University, paper 928.

[4] Behabadi, M. et al, 2015, Experimental study on heat transfer characteristics of R600a/POE/ CuO nano refrigerant flow condensation, Experimental Thermal & Fluid Science, 66 p. 46- 52.

[5] Bi, S., et al, 2011a, Performance of domestic refrigerator using TiO2-R600a nano-refrigerant as working fluid, Energy Conversion and Management, 52, p. 733–737.

[6] Bi,S., et al., 2008b, Application of nano particles in domestic refrigerators, Applied Thermal Engineering, 28, p. 1834–1843.

[7] Cheng, L., Liu, L., 2013, Boiling and two-phase flow phenomena of refrigerant- based nanofluid: Fundamentals, applications and challenges, International Journal of Refrigeration, 36, p. 421-446.

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