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Design and Analysis of Elliptical Tube Condenser in Refrigerator

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ABSTRACT

In frameworks including heat move, a condenser is a gadget or unit used to consolidate a substance from its vaporous to its fluid state, regularly by cooling it. In this manner, the inactive warmth is surrendered by the substance, and will move to the condenser coolant. Condensers are normally heat exchangers which have different plans and come in numerous sizes going from somewhat little to huge modern scale units utilized in plant measures. Air cooled condensers are utilized in little units like family fridges, profound coolers, water coolers, window forced air systems, split forced air systems, little bundled climate control systems and so on These are utilized in plants where the cooling load is little and the complete amount of the refrigerant in the refrigeration cycle is little. Air cooled condensers are likewise called loop condensers as they are typically made of copper or aluminum curl. Air cooled condensers consume a nearly bigger space than water cooled condensers. In this work heat move by convection in air cooled condensers is considered and improved. The evaluation has been done on an air-cooled finned-tube condenser of a fume pressure cycle for cooling framework. Heat transfer analysis and CFD analysis is done on the condenser to evaluate the better design. Instead of circular cross section elliptical cross sectional pipes are incorporated in our design and its efficiency is been calculated.

KEYWORDS

Elliptical Tube, Condenser, CFD, Refrigerator, Efficiency.

Introduction

Condensers and evaporators are essentially heat exchangers in which the refrigerant goes through a stage change. Close to blowers, legitimate plan and choice of condensers and evaporators is vital for acceptable execution of any refrigeration framework. Since the two condensers and evaporators are basically heat exchangers, they share numerous things for all intents and purpose the extent that the plan of these segments is concerned. Notwithstanding, contrasts exists taking everything into account. In condensers the refrigerant fume gathers by dismissing warmth to an outer liquid, which goes about as a warmth sink. Typically, the outer liquid doesn't go through any stage change, besides in some exceptional cases, for example, in course condensers, where the outside liquid (another refrigerant) dissipates. In evaporators, the fluid refrigerant vanishes by removing heat from an outer liquid (low temperature heat source). The outside liquid may not go through stage change, for instance if the framework is utilized for reasonably cooling water, air or some other liquid. There are numerous refrigeration and cooling applications, where the outer liquid likewise goes through stage change. For instance, in a common summer cooling framework, the damp air is dehumidified by gathering water fume and afterward, eliminating the dense fluid water. In numerous low temperature refrigeration applications freezing or icing of evaporators happens. These viewpoints must be thought of while planning condensers and evaporators.In common convection type, heat move from the condenser is by lightness prompted characteristic convection and radiation. Since the stream pace of air is little and the radiation heat move is likewise not exceptionally high, the joined warmth move coefficient in these condensers is little. Therefore a generally huge gathering surface is needed to dismiss a given measure of warmth. Subsequently these condensers are utilized for little limit refrigeration frameworks like family coolers and coolers. The characteristic convection type condensers are either plate surface sort or finned tube type. In plate surface sort condensers utilized in little fridges and coolers, the refrigerant conveying tubes are joined to the external dividers of the fridge. The entire body of the cooler (with the exception of the entryway) acts like a blade. Protection is given between the external cover that acts like blade and the inward plastic front of the cooler. It is therefore that external body of the fridge is in every case

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warm. Since the surface is warm, the issue of dampness build-up on the dividers of the cooler doesn't emerge in these frameworks. These condensers are at times gotten back to as level condensers. The finned type condensers are mounted either underneath the cooler at a point or on the rear of the fridge. On the off chance that, it is mounted underneath, at that point the warm air ascends and to help it an air envelope is shaped by giving a coat on posterior of the fridge. The blade separating is kept enormous to limit the impact of fouling by dust and to permit air to stream unreservedly with little obstruction. In the more established plans, the condenser tube (in serpentine structure) was appended to a plate and the plate was mounted on the posterior of the fridge. The plate acted like a balance and warm air ascended along it. In another regular plan, dainty wires are welded to the serpentine cylinder curl. The wires act like balances for expanded warmth move territory. Figure 1.1 shows the schematic of a wire-and-cylinder type condenser ordinarily utilized in home-grown coolers. Notwithstanding the sort, fridges utilizing characteristic convection condenser ought to be situated so that air can stream openly preposterous surface.

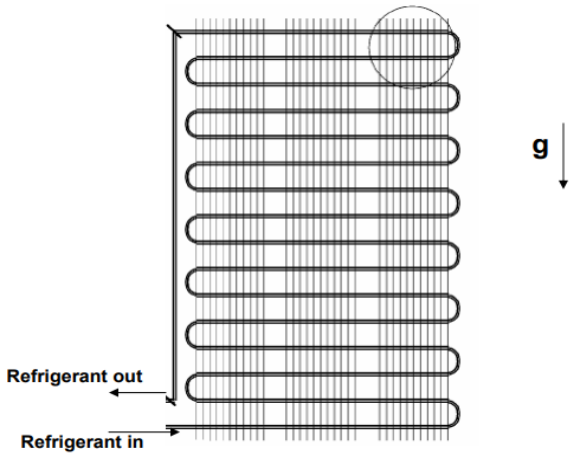

Figure 1.1. Wire and tube type condenser in small refrigeration system

Literature Review

HarshaVardhan Reddy, G.Rajasekhar Reddy, G.Phanindra, K. Vijay Kumar [1], Refrigeration frameworks have condenser that eliminates undesirable warmth from the refrigerant and moves that heat outside. The essential part of a condenser is regularly the condenser curl, through which the refrigerant streams. Since, the condenser curl contains refrigerant that ingests heat from the encompassing air, the refrigerant temperature should be higher than the air. refrigerants changed will be R 12. CFD examination is done to decide temperature appropriation and warmth move rates by fluctuating the refrigerants. Warmth move examination is done on the condenser to assess the better material. 3D modeling is done in CREO and analysis is done in ANSYS.

Arul Selvan Annamalai, R. Velraj [2], Heat pipe of one meter length and 0.031 m external distance across was developed and the analyses are led to decide the surface and fume temperature at consistent and transient conditions for two diverse info power in the evaporator segment and cooling the condenser area via air. A computational liquid elements examination was additionally conveyed and the outcomes under consistent state conditions are com-pared with the outcomes acquired from the tests.

Shah Ketul D.H.A.Vaidhya.T.B.Patel [3], the investigation of the buildup heat move coefficient inside miniature channels and small channel is still to some degree troublesome errand, especially when concentrated inside single smaller than usual channel. The neighborhood heat move coefficient will be estimated and dissected during buildup of various refrigerant with 0.3 to 3 mm measurement roundabout scaled down channel and will be thought about versus various connections. Tests are done at mass transitions going somewhere in the range of 100 and 800 kg/m2 s. The volume of liquid is utilized to follow the fume fluid interface, with the impact of shear pressure, gravity and shear strain considered. Trial and CFD information investigated to show the impact of immersion temperature, mass speeds, fume quality and liquid properties in heat move rate.

Mohammad shafiuddin, Ayubashwak, sureshvellingiri [4], CFD Fluent is used for to determine the flow rate, temperature and velocity of refrigerant flow. The materials considered for tubes are Copper and material considered

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for fins are Aluminum alloys 1100 and 1050.The refrigerants varied willbeR12, R22 and R134. 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. From the analysis results, when compared the results for fin material between Aluminum alloy 1100 and 1050, using aluminum alloy1050 is better.

N. Thangavelu, N. Mohandoss Gandhi [5], the buildup of steam on single flat copper tube in a shell and cylinder condenser has been researched utilizing test and hypothetical techniques in this investigation. The external surface of the cylinder was altered by brazing it with a copper wire longitudinally and helically to upgrade the warmth move coefficient. The impact of shifting the pitch of the helically brazed wire was concentrated with 25mm and 35mm pitch. In this work the CFD results got utilizing ANSYS 13 are approved with test results to accomplish the best act of CFD for this situation. This best practice is used to discover the best change in which pace of warmth move is greatest and the affidavit of condensate on the virus water pipe is least.

Z. Abdullah, B. Phuoc Huynh, A. Idris [6] This examination explores the impact of the warmth pipe heat exchanger in eliminating the energy and its temperature, in helping the condenser heat expulsion measure. In a typical refrigeration cycle, the warmth of a condenser at a steady pressing factor at 109200Pa and a temperature of 319K are diminished by the power convection ventilation to 315K. The temperature of the refrigerant in the cylinder is being diminished at steady pressing factor of 5K by a warmth move trade of encompassing air and the condenser tube. This reenactment showed the impact of a warmth pipe heat exchanger joined before the condenser by utilizing the computational liquid unique programming. A condenser from a refrigeration cycle with refrigerant R134a is being reproduced utilizing CFD programming. It is a benefit to utilize a warmth pipe heat exchanger to expand the temperature distinction between a refrigerant liquid at the bay and outlet of the condenser. By expanding the warmth move pace of the warmth pipe and the condenser tube, thus bringing down the condenser temperature yield, the framework limit will increment.

Simon Hecker, Andreas Auge, Tobias Ellsel, Johan Flegler, Christian Musch, Arne Grabmann [7], This investigation presents the change of a business CFD code to mimic the three-dimensional stream field around and inside tube groups. Moreover the temperature dispersion of the cooling water is important for the mathematical arrangement without displaying every individual condenser tube.To show the exactness of the CFD code the stream in an enormous scope power plant condenser is recreated and contrasted with estimations of nearby warmth move coefficients in the groups. The examination shows that the introduced CFD apparatus is substantial to foresee the presentation of such condensers. Based on the aftereffects of the investigation, territories with low cooling execution are recognized and ideas are made for the increment of the general condenser effectiveness.

Chavan Karthik, M. Naveen Kumar [8], 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 transferred to the surrounding environment. 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).In this project we will design condenser tubes with proper dimensions. The material of tubes is made up of copper and fins are varying with different materials like Aluminum 1100 and Aluminum 1050.The refrigerants varied will be R 12, R 22 and R134. The refrigerants areHeat transfer analysis done on condenser by using ANSYS CFD (Fluent) and modeling of the condenser tubes is done in SOLIDWORKS.CFD Fluent is used for to determine the heat transfer rate, temperature and velocity of refrigerant flow.

Design & Analysis

Solid Works is a strong modeler, and uses a parametric component based way to deal with make models and congregations. The product is composed on Para strong bit. Boundaries allude to requirements whose qualities decide the shape or calculation of the model or gathering. Boundaries can be either numeric boundaries, for example, line lengths or circle breadths, or mathematical boundaries, like digression, equal, concentric, level or vertical, and so on Numeric boundaries can be related with one another using relations, which permits them to catch plan purpose. Sectional view of circular and elliptical tube shown in figure 3.1 and 3.2.

Linear length is 272.24mm
Circumference of semicircle is 157.08mm
Since we have 18 turns on our model so,
Total length of curvature is 157.08*18=2827.44mm

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Also we have 19 linear pipes in our model so,
Total length by linear pipe is 272.24*19=5172.56 mm
Total length of pipe used for condenser=5172.56+2827.44=8000mm

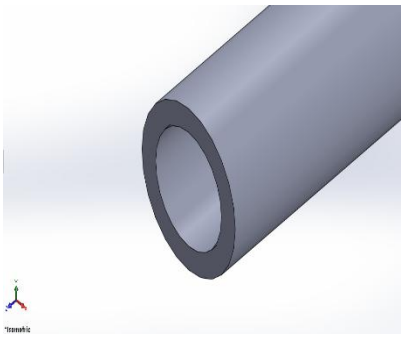

Figure 3.1. Circular cross section

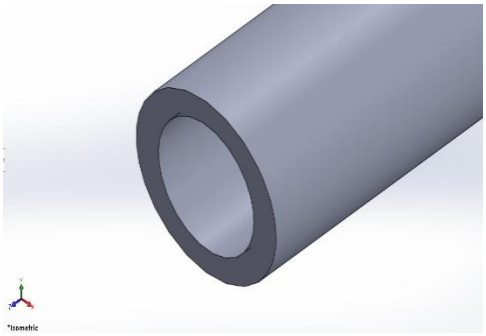

Figure 3.2. Elliptical cross section

ANSYS Workbench consolidates the strength of our center reproduction devices with the apparatuses important to deal with your activities. You will work with your ANSYS Workbench project on the fundamental venture workspace, called the Project tab. The undertaking is driven by a schematic work process, addressed outwardly on a flowchart like graph called the Project Schematic. To fabricate an investigation, you add building blocks called frameworks to the Project Schematic; every framework is a square of at least one parts called cells, which address the consecutive advances important for the particular kind of examination. Whenever you have added your frameworks, you can interface them together to share as well as move information between frameworks. From the cells in the Project Schematic, you can work with different ANSYS applications and examination undertakings. A portion of these open in tabs inside the Workbench climate, while others open freely in their own windows. ANSYS applications permit you to determine boundaries like math boundaries, material properties and limit conditions. Boundaries can be characterized inside the application and oversaw at the undertaking level in the Workbench climate. There is a developing proof of advantages accumulating from the consolidated information on both FDM and FEM. Limited volume strategies (FVM), in light of their basic information structure, have gotten progressively famous lately, their plans being identified with both FDM and FEM. The stream field-subordinate variety (FDV) strategies additionally highlight connections among FDM and FEM. we are trying to perceive such perspectives and to seek after the upside of contemplating FDM and FEM together on an equivalent balance. Truly, FDMs have ruled the CFD people group. Straightforwardness in plans and calculations added to this pattern. FEMs, then again, are known to be more muddled in plans and additional tedious in calculations. Nonetheless, this is not true anymore in large numbers of the new improvements in FEM applications. For Detailed description, readers are referred to other textbooks, which are devoted to this CFD provides numerical approximation to the equations that govern fluid motion. Application of the CFD to analyze a fluid problem requires the following steps. First, the mathematical equations describing the fluid flow are written. These are usually a set of partial differential equations. These equations are then discretized to produce a numerical analogue of the equations. The domain is then divided into small grids or elements. Finally, the initial conditions and the boundary conditions of the specific problem are used to solve these equations. The solution method can be direct or iterative. In addition, certain control parameters are used

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to control the convergence, stability, and accuracy of the method. The Meshed surface of pipes shown in figures 3.3 and 3.4.

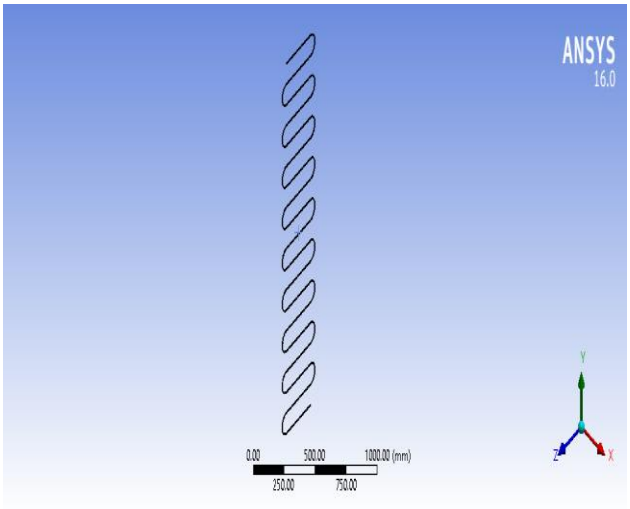

Figure 3.3. Meshed view of pipe

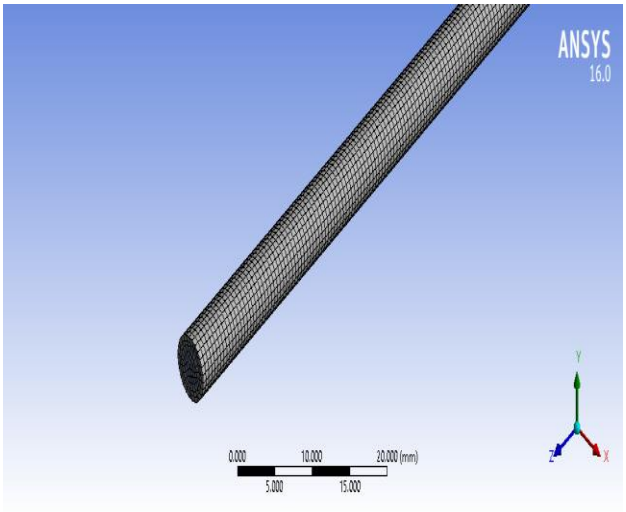

Figure 3.4. Mesh distribution on pipe surface

Results & Discussion

This section presents the standard, RNG, k-ε realizable models. All three models have similar forms, with transport equations fork-ε. The major differences in the models are method of calculating turbulent viscosity. The turbulent Prandtl numbers governing the turbulent diffusion of k-ε. The generation and destruction terms in the k-εequation. The transport equations, methods of calculating turbulent viscosity, and model constants are presented separately for each model. The features that are essentially common to all models follow, including turbulent production, generation due to buoyancy, accounting for the effects of compressibility, and modelling heat and mass transfer. Fluid medium used ammonia vapour and solid material used Copper. The Boundary conditions are Pressure inlet (1285400 Pa), Temperature (322.8 k) Atmospheric Temperature (300 k) and Pressure outlet.Temperature and pressure distributions of circular and elliptical pipe inlet and outlet sections were analysed and figured out in below figures 4.1- 4.8.In table 4.1 represents the inlet and outlet values of pressure and temperatures of pipe inlet as well as pipe outlet.

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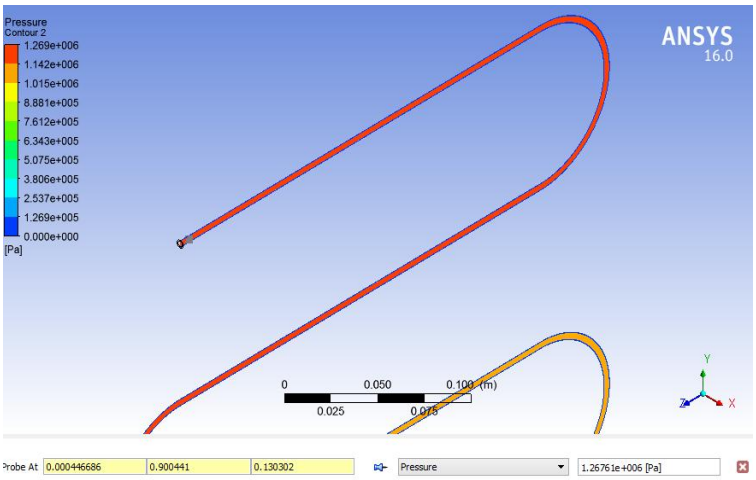

Figure 4.1.C-tube Pressure Inlet distribution

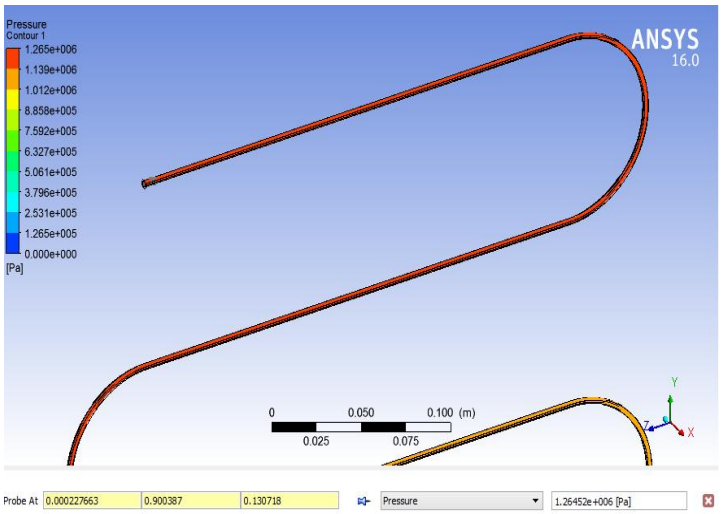

Figure 4.2.E-tube Pressure Inlet distribution

Figure 4.3.C-tube Pressure Outlet distribution

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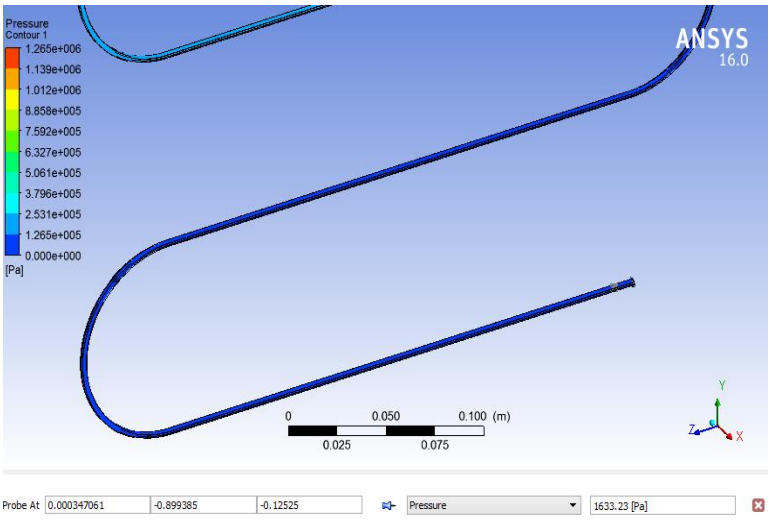

Figure 4.4.E-tube Pressure Outlet distribution

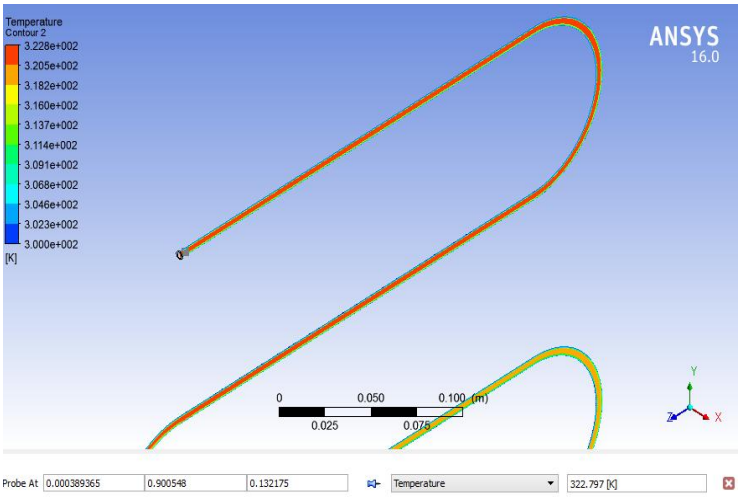

Figure 4.5.C-tube Inlet Temperature distribution

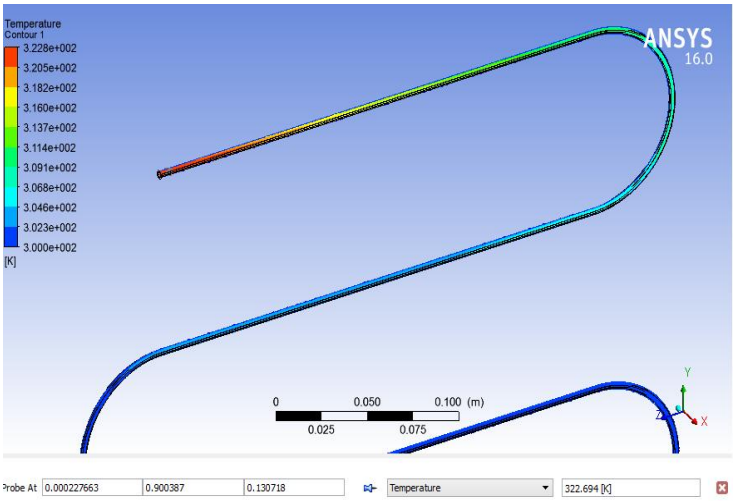

Figure 4.6.E-tube Inlet Temperature distribution

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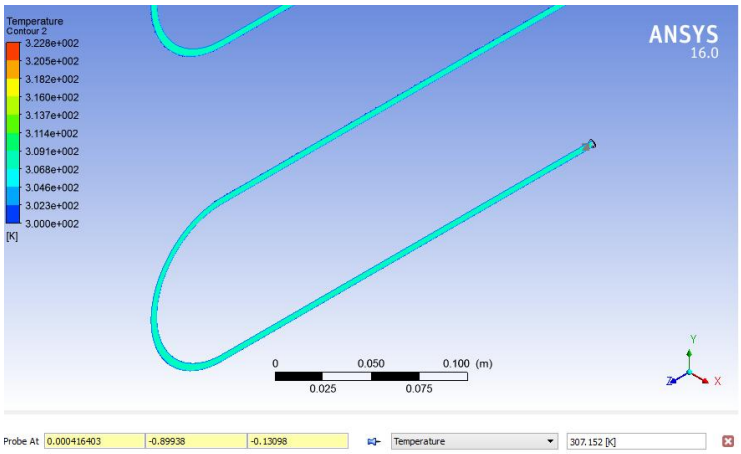

Figure 4.7.C-tube Outlet Temperature distribution

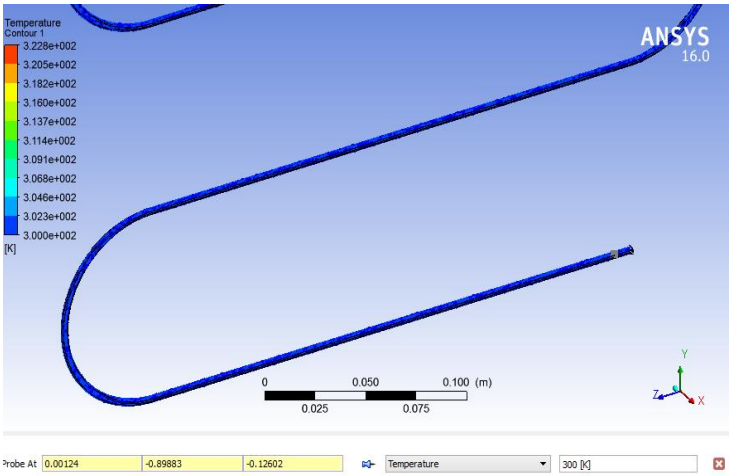

Figure 4.8.C-tube Outlet Temperature distribution

Table 4.1. Comparison of circular and elliptical tube

	Pressure (Pa)		Velocity (m/s)		Temperature (K)	
Cross section	**Inlet**	**Outlet**	**Inlet**	**Outlet**	**Inlet**	**Outlet**
Circular	$1.26e^{6}$	826.95	226.02	239.61	322.79	307.15
Elliptical	$1.26e^{6}$	1633.23	245.04	256.55	322.69	300

Conclusion

The CFD analysis of an air cooled condenser heat pipe with two different cross sectional geometries are carried out and the results are reported. The temperature variation along the length of heat pipe at various stages explains clearly the process of evaporation and condensation that occurs inside the heat pipe at various stages of operation. As surface heat flux in the evaporator increases the operating temperature of the heat pipe also increases which is due to the surface convective resistance of the condenser region. In the present case with air as the cooling medium in the condensersection, thelowsurface convectiveheattransfercoefficient istheinfluencing resistancewhichaffectstheperformanceofthecondensingprocessand sequentiallythe evaporation process in the heat pipe. For efficient operation of the heat pipe, the elliptical cross sectional area is preferred which provides effective temperature drop when compared with the existing circular cross sectional area. In use of equivalent area for circular and elliptical tube the total area were maintained as constant for both cases but the pressure drop and temperature fall in elliptical tube is more efficient as compare to circular tube.

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