EXPERIMENTAL INVESTIGATION AND TEMPERATURE DISTRIBUTION OF AUTOMOBILE RADIATOR USING NANO FLUIDS

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ABSTRACT

In internal combustion engine as piston moves inside the cylinder at very faster rate s it is very necessary to keep the temperature inside the engine at the moderate level so that the engine performance should not get affected. In order to achieve this task we required the continuous cooling surrounding the engine through water jacket and as the water surrounding the IC engine is get heated up very rapidly so a system should be required to keep this water circulated through a medium which controls the heating of water upto a desired level to do so radiator in an automobile is accomplished the desired objective. The system of radiator is consist of storage tank, supply pipe line, tubes with n number of passes, fins, inlet and outlet system, thermostat, pressure control unit etc.

Keywords*:* *Radiator, mass flow rate, temperature distribution, Nano fluid.*

INTRODUCTION

In present world all most all of us early being in a century that growing with a very fast rate and requires the persons to be very punctual in whatever work they are doing with great preciseness. In order to achieve the day to day goals one cannot live rely only on what got gifted us from nature. So we must use gadgets such as mobile phones, computers, printers, vehicles etc. to get that work done with very low amount of energy to do and with a higher rate of accuracy, punctuality and simplicity. Automobile is a new form of vehicle which moves not only on wheels but using the automated systems like motors, accelerators, lighting system, air conditioner embedded with them and even some of them have calibre to save nature by using green fuels. So as we see from day to day automobiles are getting loaded to achieve the human desire up to that level of mark that never is think by our ancestors.

From the above summary it is necessary to have preventive as well as breakdown maintenance of the automobiles in a very quality manner so that the customer satisfaction can be meet and the companies have greater sells year after year.

In order to improve the vehicle performance and durability it is necessary that one should keep as much as preventive maintenance breakdown must be minimise with the lowest possible price and preventive maintenance should also be done in such a fashion that vehicle while running can always run in a moderate zone which is unaffected to their performance.

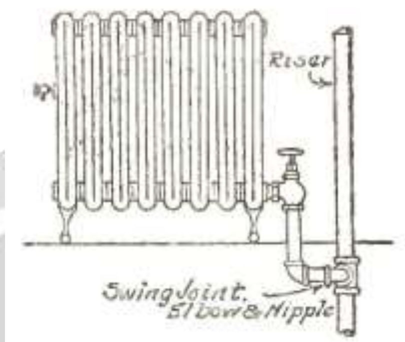
Components of Radiator:

Water Pump:

This is a centrifugal type pump. It is centrally mounted at the front of the cylinder block and is usually driven by means of a belt. This type of pump consists of the following parts: (i) body or casing, (ii) impeller (rotor), (iii) shaft, (iv) bearings, or bush, (v) water pump seal and (vi) pulley.

The bottom of the radiator is connected to the suction side of the pump. The power is transmitted to the pump spindle from a pulley mounted at the end of the crankshaft. Seals of various designs are incorporated in the pump to prevent loss of coolant from the system.

Fan:
The fan is generally mounted on the water pump pulley, although on some engines it is attached directly to the crankshaft. It serves two purposes in the cooling system of a engine.
(i) It draws atmospheric air through the radiator and thus increases the efficiency of the radiator in cooling hot water.
(ii) It throws fresh air over the outer surface of the engine, which takes away the heat conducted by the engine parts and thus increases the efficiency of the entire cooling system.



Objective of the thesis:

In present work our objective to analyse the radiator of light commercial vehicle for getting optimal performance. There are some important points described below to specify the core objective of the research work-
1. We will select a model of a radiator of light commercial vehicle based on the literature and research which is available to till date.
2. As radiator is a one type of heat exchanger so its performance can be evaluated on the basis of heat flux, rate of heat transfer through whole surface and distribution of temperature along the radiator tubes and also in radial direction.
3. Performance parameter mentioned above is estimated for different arrangement of the radiator and graph will be plotted between the parameters.

LITERATURE REVIEW

Dwivedi, V. D., &Rai, R.,[1]In modern gas turbines, the operating temperature of the turbine blades is higher than the melting point of the blade material. For the safe and continuous operation of high-performance gas turbines, a sophisticated cooling system must be developed. Various methods have been proposed for blade cooling, and such technique involves drilling radial holes to allow cooling air to flow at high velocity over the entire blade span. In the present wormathk, the analysis of the heat transfer of a gas turbine with four different models was analyzed, including a morning without holes and blades with a variable number of holes (5, 9 and 13) Model k-real (feasible with improved wall treatment) was used. In evaluating the graphs of total heat transfer rate and temperature distribution, the 13-hole blade is considered optimal.

Amrutkar, P. S., &Patil, S. R.,[2] The proposed work deals with the development of an Excel spreadsheet for the calculation of heat output. Only a few input parameters give a precise idea of the heat output. The blade helps to estimate the influence of variations in pipe and fin density, coolant flow, etc. on heat output. Theoretical calculation of the size of the cooler core and the heat output for a given engine power.Validation of the core size by a simulation software and comparison of the theoretical heat release with the results of the simulation. Optimize kernel size based on heat dissipation requirements. 3D modeling of the collector, tubes, fins and tanks of the radiator components. Finite element analysis of the radiator to test its robustness against thermal and pressure loads. Development of a prototype for the validation of the cooler performance

Yadav, J. P., & Singh, B. R.,[3] In this paper, forced convective heat transfer in a water based nanofluid has experimentally been compared to that of pure water in an automobile radiator. Five different concentrations of nanofluids in the range of 0.1-1 vol. % have been prepared by the addition of TiO2 nanoparticles into thewater. The test liquid flows through the radiator consisted of34 vertical tubes with elliptical cross section and air makes across flow inside the tube bank with constant speed. Liquidflow rate has been changed in the range of 90-120 l/min tohave the fully turbulent regime. Results demonstrate thatincreasing the fluid circulating rate can improve the heat transfer performance. Meanwhile, application of nanofluid with low concentrations can enhance heat transfer efficiency up to 45% in comparison with pure water.

Bhimani, V. L., Rathod, P. P., &Sorathiya, A. S.,[4] In this article, experimental heat transfer coefficients in the automobile radiator have been measured with two distinct working liquids: pure water and water based nanofluid (small amount of TiO2 nanoparticle in water) at different concentrations and temperatures and the following conclusions were made.

1. The presence of TiO2 nano particle in water can enhance the heat transfer rate of the automobile radiator. The degree of the heat transfer enhancement depends on the amount of nano particle added to pure water. Ultimately, at the concentration of 1 vol. %, the heat transfer enhancement of 40-45% compared to pure water was recorded.
2. Increasing the flow rate of working fluid (or equally Re) enhances the heat transfer coefficient for both pure water and nanofluid considerably.
3. It seems that the increase in the effective thermal conductivity and the variations of the other physical properties are not responsible for the large heat transfer enhancement. Brownian motion of nanoparticles maybe one of the factors in the enhancement of heat transfers. Although there are recent advances in the study of heat transfer with nanofluids, more experimental results and theoretical understanding of the mechanisms of the particle movements are needed to explain heat transfer behavior of nanofluids.

Ali, H. M., Azhar, M. D., Saleem, M., Saeed, Q. S., &Saieed, A.,[5] The focus of this research paper is on the application of water based MgOnanofluids for thermal management of a car radiator. Nanofluids of different volumetric concentrations (i. e. 0.06%, 0.09%, and 0.12%) were prepared and then experimentally tested for their heat transfer performance in a car radiator. All concentrations showed enhancement in heat transfer compared to the pure base fluid. A peak heat transfer enhancement of 31% was obtained at 0.12% volumetric concentration of MgO in basefluid. The fluid flow rate was kept in a range of 8-16 liter per minute. Lower flow rates resulted in greater heat transfer rates as compared to heat transfer rates at higher flow rates for the same volumetric concentration. Heat transfer rates were found weakly dependent on the inlet fluid temperature. An increase of 8 °C in inlet temperature showed only a 6%increase in heat transfer rate. In this paper, the convective heat transfer enhancement of automobile car radiator has been experimentally studied by using MgO water based nanofluids at different flow rates and at various volumetric concentrations to study their behavior. The following major conclusions are obtained.

Pendyala, R., Chong, J. L., &Ilyas, S. U.,[6] Nanofluids are the new developed thermal fluids with enhanced thermophysical properties which can improve heat transfer performance of various applications. By introducing nanoparticles with high thermal conductivity in the car radiator coolant can enhance the effective thermal conductivity of coolant which improves the performance of cooling system. Alumina, silica and copper oxide nanoparticles with ethylene glycol-water mixture (60:40) have been used in 3-dimentional car radiator simulations to study fluid flow patterns and heat transfer performance. Heat transfer performance for ethylene glycol-water mixture based nanofluids at different nanoparticle concentrations has been studied. Heat transfer coefficients are determined by numerical simulations with varying coolant velocities. Overall heat transfer performance is found to be improved using nanofluids with high effective thermal conductivity. Results display significant increase in heat transfer performance of coolant in car radiator with an increase in the particle loading.

Vasu, V., Krishna, K. R., & Kumar, A. C. S.,[7] Compact heat exchangers have been widely used in various applications in thermal fluid systems including automotive thermal fluid systems. Radiators for engine cooling systems, evaporators and condensers for HVAC systems, oil coolers and inter coolers are typical examples that can

be found in ground vehicles. Recent development of Nanotechnology brings out a new heat transfer coolant called 'Nanofluids' these fluids exhibit larger thermal
properties than conventional coolants (water, Ethylene glycol, Engine oil etc.) due to the presence of suspended nanosized particles in then such as Al_2O_3, Cu,CuO,TiO_2 etc. In this paper a theoretical analysis was carried with ε – NTU rating method by using Al_2O_3 + H_2O Nanofluid as coolant on automobile flat tube plain fin compact heat exchanger and different characteristics are graphically presented.

MATHEMATICAL MODELLING

In this module we will model the radiator of a heavy duty vehicle called truck engine. For the mentioned purpose we have taken a matador truck engine for mathematical calculation of the problem. The concern engine is coolant by a mixture of ethylene glycol and water. This coolant is flow in the tubes of the radiator. The specification for the mathematical analysis of the radiator is being taken by problem of internal combustion engine textbook by John B. Heywood. The inlet outlet conditions and other important parameter of the radiator is given below-

Inlet temperature of the coolant = 180 ^{0}C

Exit temperature of the coolant = 110 ^{0}C

Mass flow rate of the coolant = 1 kg/s

Density of the coolant = 1090 kg/m^3

Diameter of the tube = 20mm

Thermal conductivity of the tube (aluminium) = 120 W/mk

Thickness of the tube = 2 mm

Number of tubes in the radiator = 17

Length of the tube = 1200 mm

According to the principle of energy conservation heat rejected by the coolant will be equal to the heat gained by the air.

Heat rejected by the coolant is given by Q = Mc×Cpc×dT

Where Mc is the mass flow rate of the coolant

Cpc is the specific heat of the coolant

dT is the temperature difference of the coolant from inlet to exit.

Q= 1 kg/s×2.42 kj/kg-k×70 ^{0}C

Q = 169.4kw

ANALYSIS AND SIMULATION

The geometry of radiator is partially made in mechanical design software namely CATIA V5R12 and saved as an IGES file format to get it readable in ANSYS modeller. The figure 4.1 represents the imported geometry of single bend tube in ANSYS workbench 14.01.

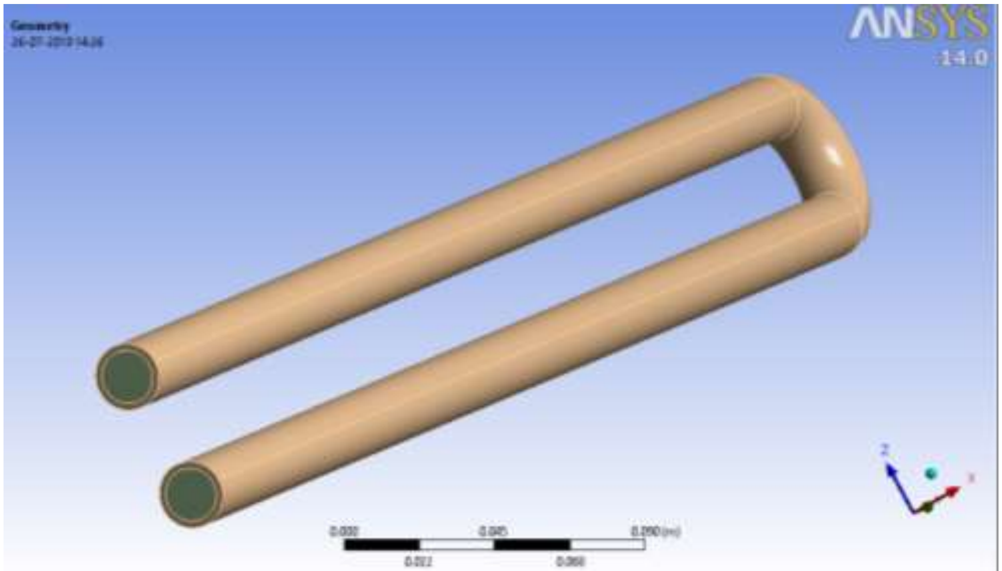


Figure 4.1 Geometry of radiator tube

Some contact between the fluid and pipe wall should be define in the connection module of ANSYS 14.0. here the frictionless connection is provided between the two mating surfaces as shown in figure 4.2

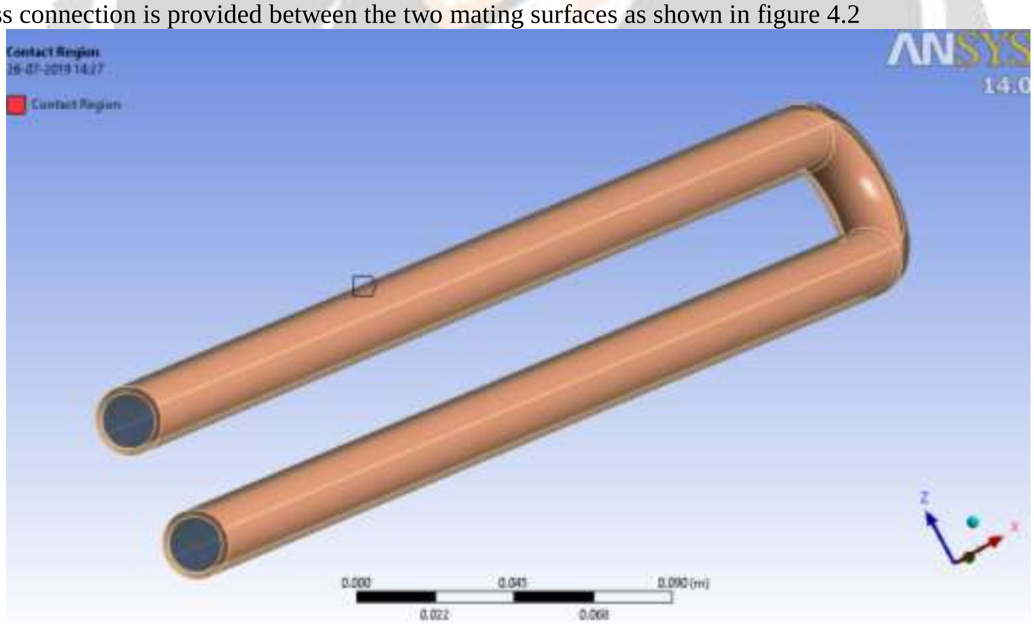


Figure 4.2 Connection between solid fluid and cooling fluid

Now the discretization of two geometry of solid hollow tube and the inner coolant geometry is done using tetrahedron type of mesh element by using ANSYS mesh modeller and is represented in figure 4.3 below

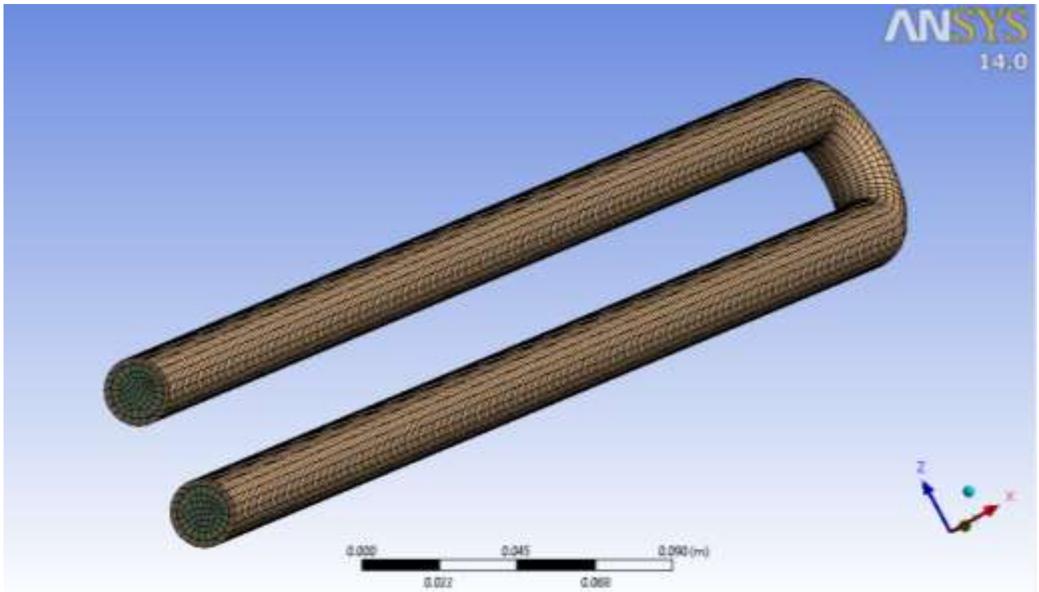


Figure 4.3 Meshing of radiator tube with coolant

The boundary conditions have to be defined for solving the aforesaid problem for which we have provided some named selection in the internal solid which is defined as legrangian fluid the one end is provided as the intake to the fluid and another is provided as the outlet. Here we have provided as the mass flow inlet with the value equal to 1 kg/sec whereas the pressure outlet is defined as the outlet of the coolant. The boundary conditions are shown in the figure 4.4.

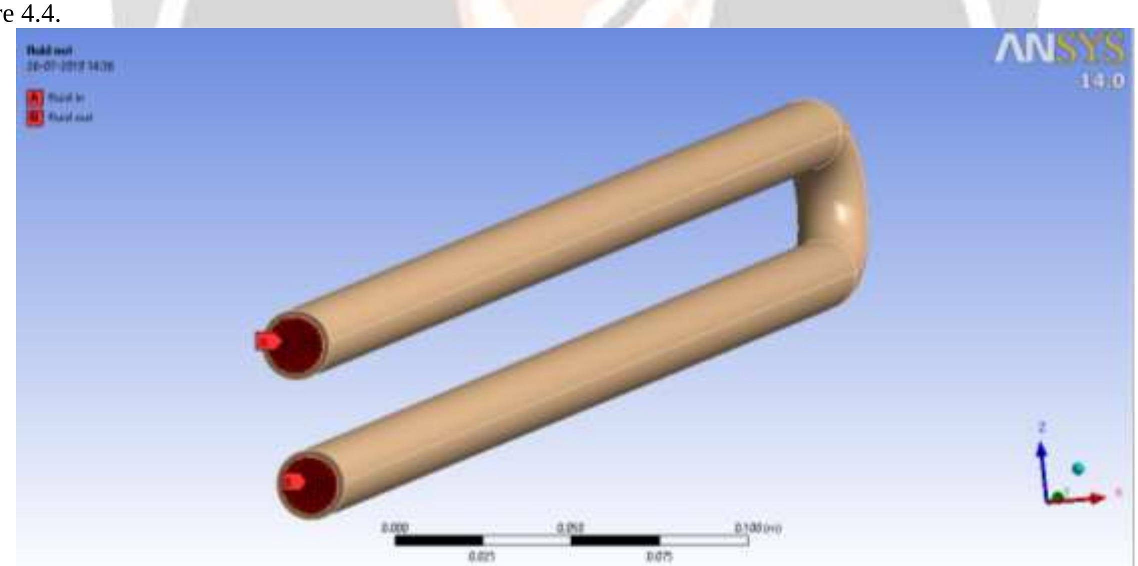


Figure 4.4 Inlet and outlet boundaries

There are a variety of coolants which can be used to cool the engine and are used in the radiator for cooling purpose and one of the most commonly used coolant is water based ethylene glycol and so we have also taken as the standard to check whether the other nano fluid will be compatible and effective or not.

The figure 4.5 below represents the value of heat flux by considering ethylene glycol as flowing fluid insight the aluminium hollow tube. As seen from the figure that the value of heat flux is 33810 w/m^2.

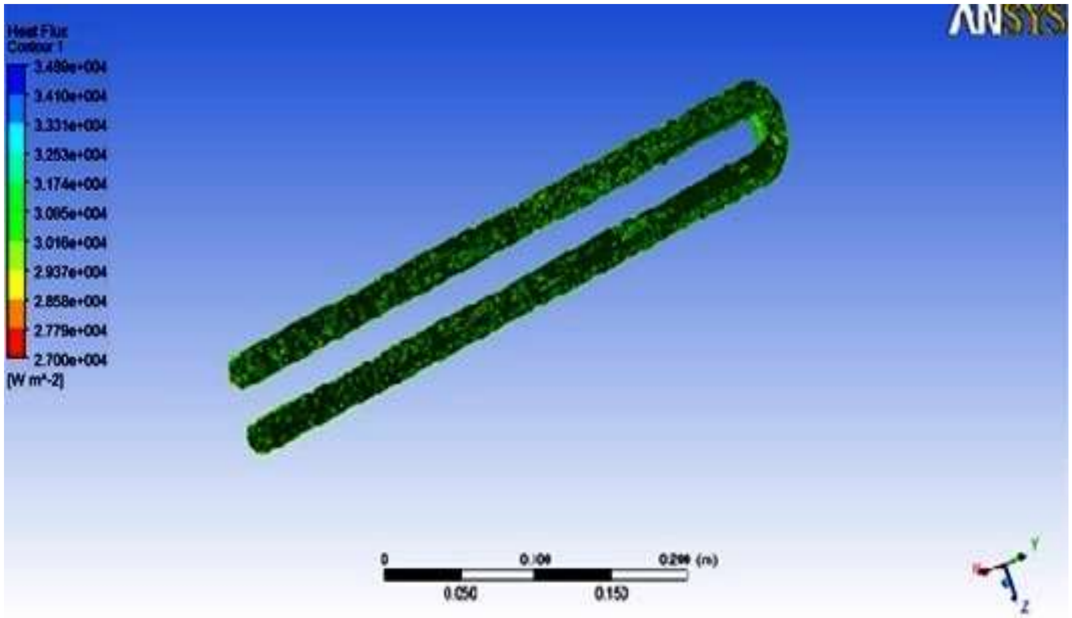


Figure 4.5 heat flux for ethylene glycol as coolant

The figure 4.6 below represents the value of heat flux by considering Cu-O (nano fluid) as flowing fluid insight the aluminium hollow tube. As seen from the figure that the value of heat flux is 34890 w/m^2. Which is slightly higher than the conventional ethyelene glycol cooling material.

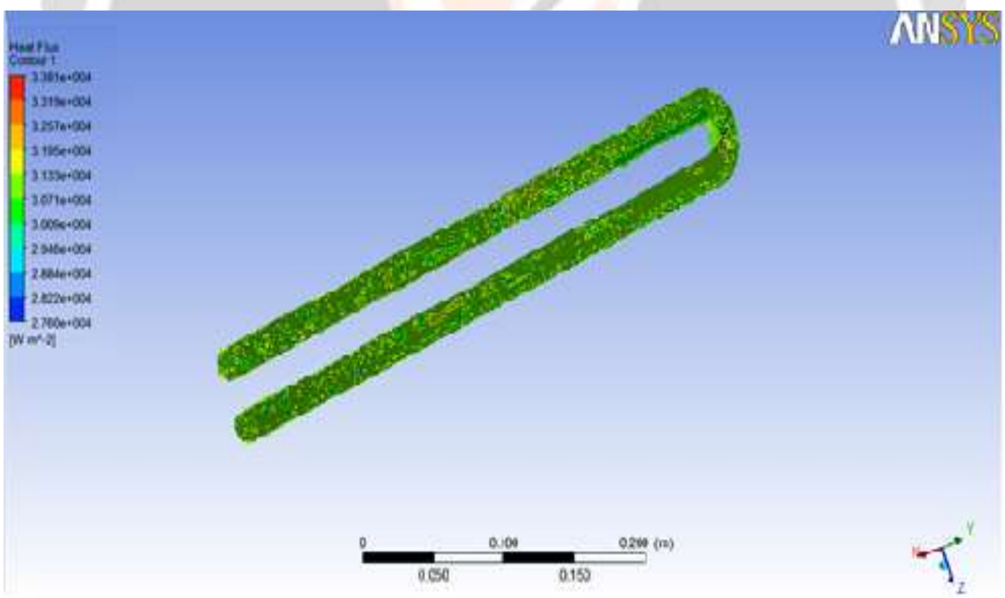


Figure 4.6 heat flux for Cu-O as coolant

The figure 4.7 below represents the value of heat flux by considering ethylene glycol as flowing fluid insight the aluminium hollow tube. As seen from the figure that the value of heat fluxwith fin geometry is 71210 w/m^2.

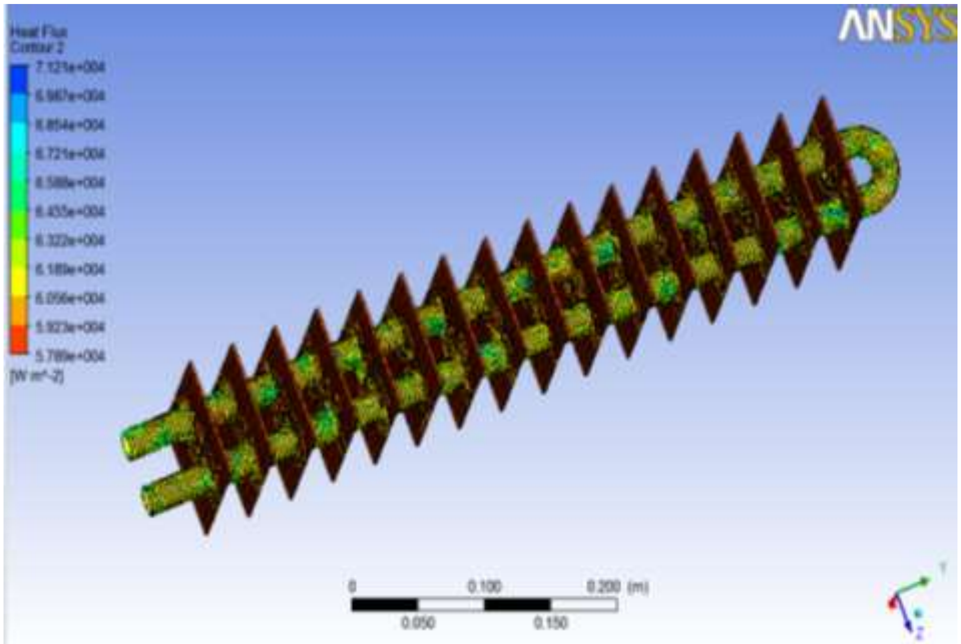


Figure 4.7 heat flux for ethylene glycol as coolant with fin geometry

The figure 4.8 below represents the value of heat flux by considering Cu-O (nano fluid) as flowing fluid insight the aluminium hollow tube. As seen from the figure that the value of heat flux with fin geometry is 72490 w/m^2. Which is slightly higher than the conventional ethyelene glycol cooling material.

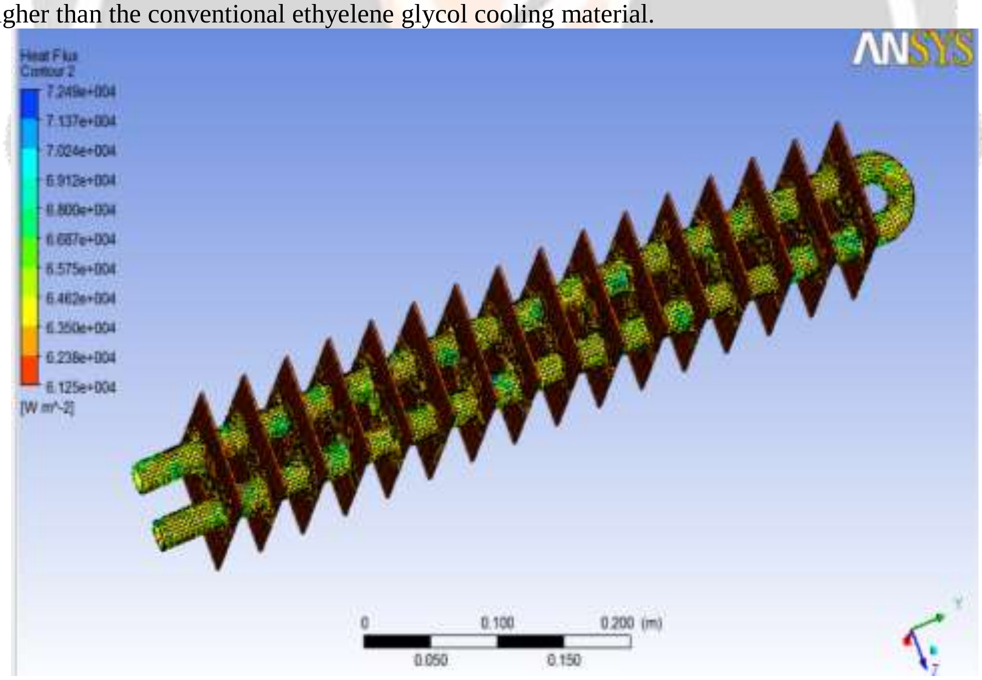


Figure 4.8 heat flux for Cu-O as coolant with fin geometry

The figure 4.9 below represents the value of temperature distribution by considering ethylene glycol as flowing fluid insight the aluminium hollow tube. As seen from the figure that the minimum value of temperature distribution is 373 K.

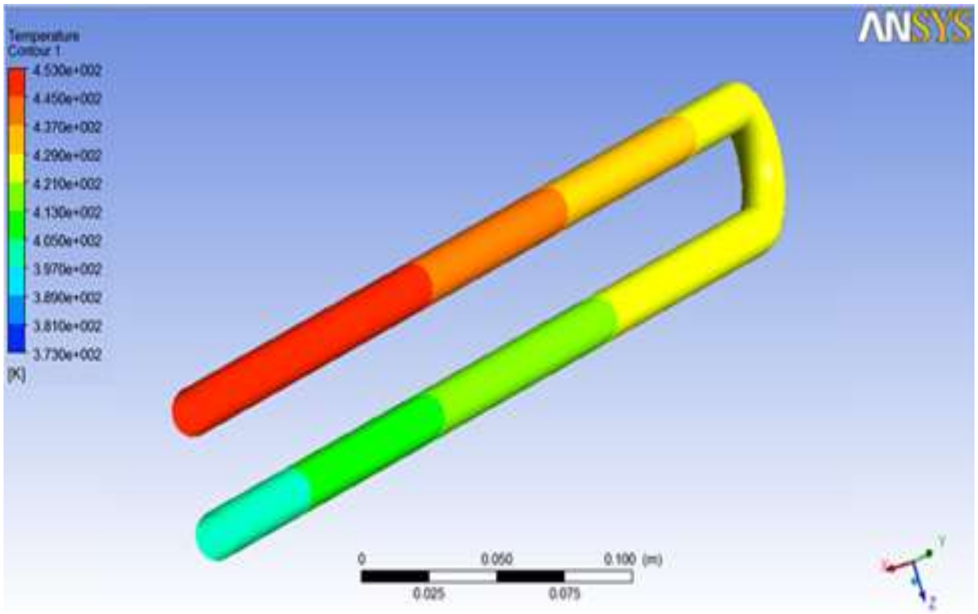


Figure 4.9 temperature contour with ethylene glycol as coolant

The figure 4.10 below represents the value of temperature distribution by considering ethylene glycol as flowing fluid insight the aluminium hollow tube. As seen from the figure that the minimum value of temperature distribution with fin geometry is 330 K.Which is significantly lesser then the geometry without fin.

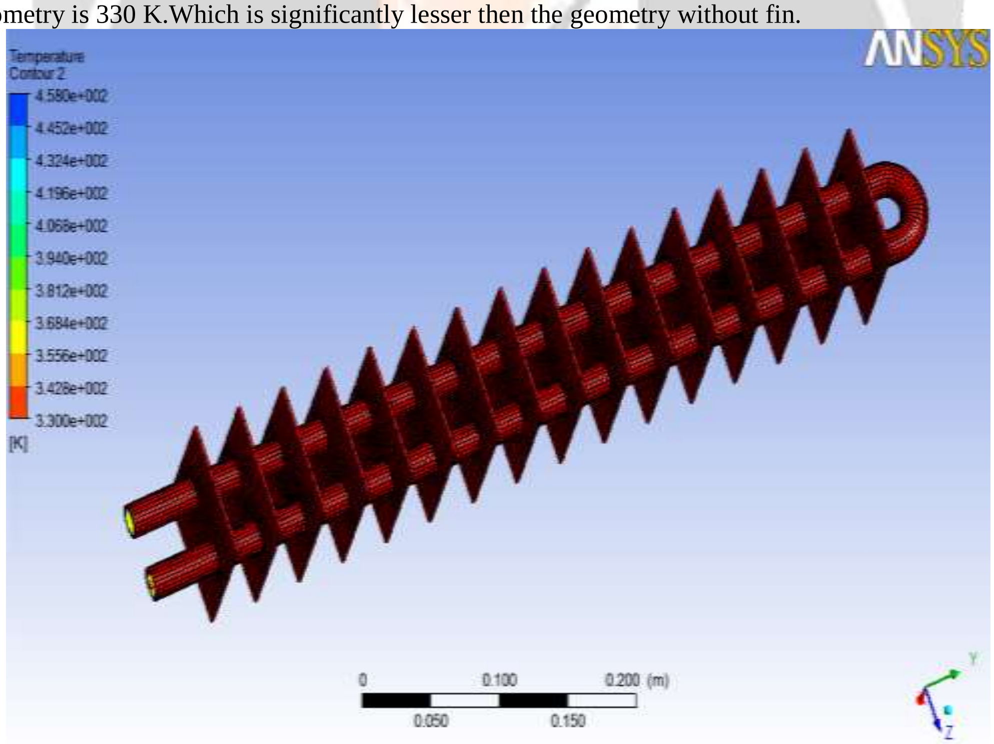


Figure 4.10 temperature contours with ethylene glycol as coolant with fin geometry

The figure 4.11 below represents the value of temperature distribution by considering Cu-O (nano fluid) as flowing fluid insight the aluminium hollow tube. As seen from the figure that the minimum value of temperature distribution is 344 K.

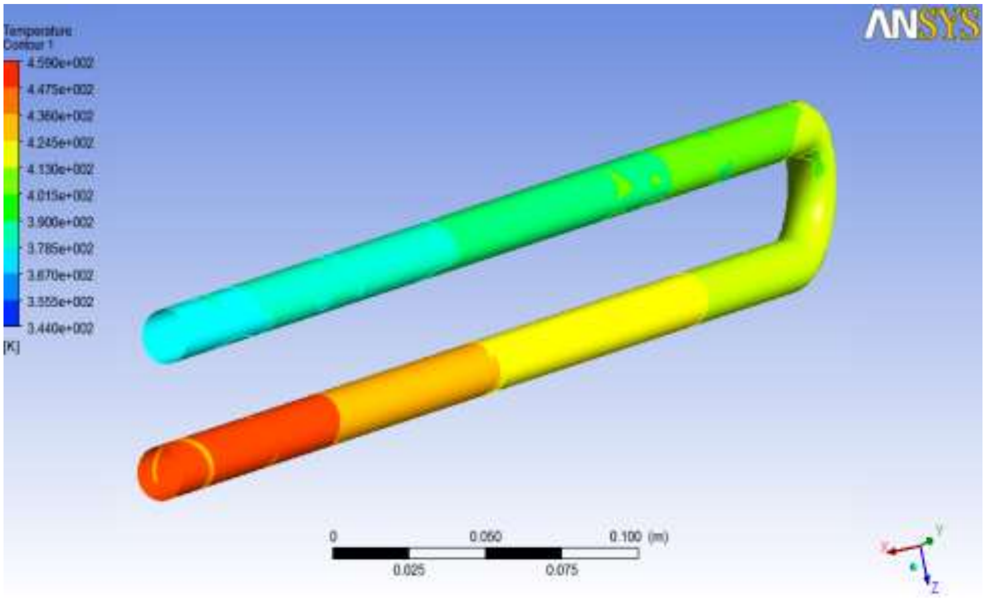


Figure 4.11 temperature contour with Cu-O as coolant

The figure 4.12 below represents the value of temperature distribution by considering Cu-O (Nano fluid) as flowing fluid insight the aluminium hollow tube. As seen from the figure that the minimum value of temperature distribution with fin geometry is 315 K.Which is considerably lower than the geometry without fin.

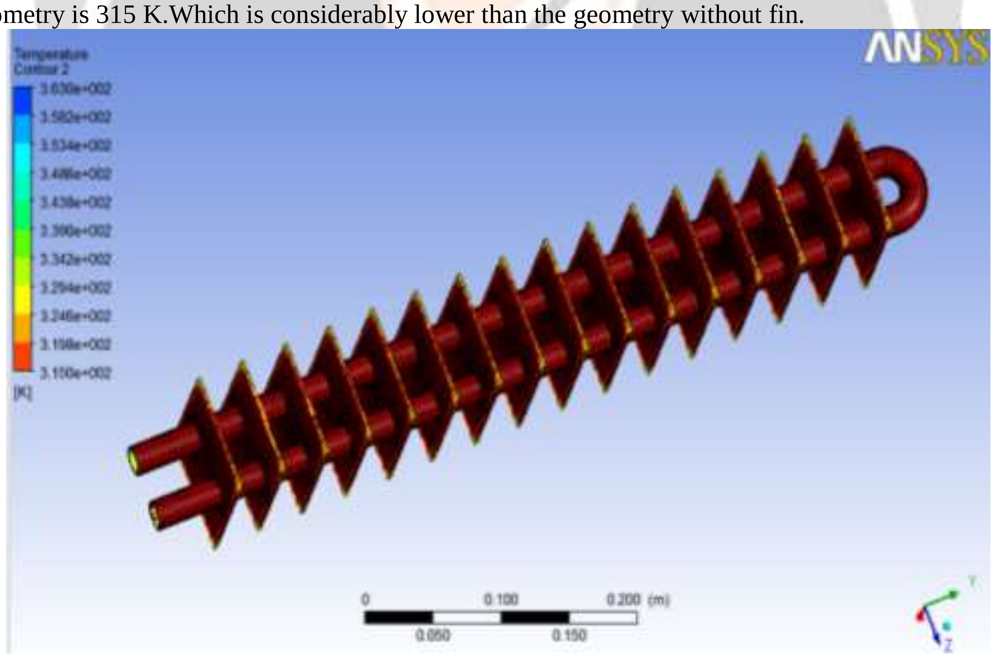
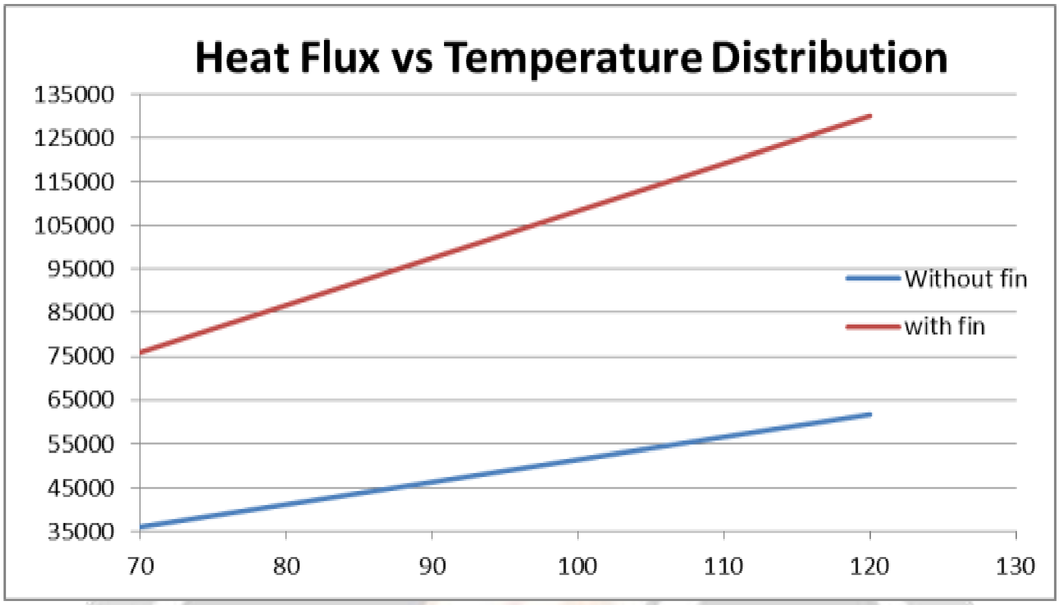


Figure 4.12 temperature contours with Cu-O as coolant with fin geometry

RESULT AND DISCUSSION



Conclusion

1. The effectiveness of the radiator are obtained from the results are greater than unity that is 2.025566 in our case, which implies that the use of fin with radiator tube is effective and helpful to transfer the heat of cooling fluid.
2. It has been seen that with the use of Cu-O as Nano fluid the heat flux will increases in both the cases. In our case the value of heat flux without fin will increase up to 3%. And if the same is used with fin then it will also increase up to around 2%.
3. The minimum possible temperature in case of without fin geometry considering ethylene glycol as coolant is 373 k while the temperature goes to decrease up to 374 k when we use the Nano fluid (Cu-O) as coolant.
4. The minimum possible temperature with fin geometry considering ethylene glycol as coolant is 330 k while the temperature goes to decrease up to 315 k when we use the Nano fluid (Cu-O) as coolant.

Future Scope:

After investigation and analysis of the radiator by use of simulation and mathematical modelling we satisfy with the results obtained from the ANSYS, there are some more scope is also present for future perspective from the research point of view and one can extend these work under the following points of consideration, out of which some important points are mentioned below:

1. One can iterate the material of the radiator and investigate the thermodynamic parameter of the radiator.
2. One can change the types of coolant used in the radiator and get the optimised results by investigation.
3. Some additional techniques like extended surface and moderation of the geometry in the fins can also be possible for get desired heat transfer in optimised way.
4. One can also use these exergy (rejected heat or unavailable energy) from the radiator tube and do some useful work.

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