NUMERICAL STUDIES ON HEAT TRANSFER CHARACTERISTICS OF HEAT PIPES USING NANO FLUIDS

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Abstract -Efficiency of almost all the electrical components increases with a decrease in temperature. By the transfer of heat. This report focuses on heat transfer from an object at higher temperature to maintain an optimum working condition. The mode of heat transfer is passive. A numerical study has been carried out in this research. Heat Pipe which is an enhanced technique in the field of such work is being used. Silver based Nano Fluid is employed as the working medium. A theoretical model has been proposed in order to study the heat transfer performance of the Nano Fluids. A comparison is shown between the conventional fluids such as Water and Silver based Nano Fluid. Heat pipe works on the concept of convective heat transfer. The Volume of Fluid method has been implied in the physics of the problem to solve the continuity, momentum and energy equation. The measured results also show that the thermal resistance decreases with an increase in the concentration of the Nano Fluids. Ansys 18.1 has been employed to carry out the numerical analysis.

***Key Words*:**Heat pipe, Nano fluid, conduction, thermal,

1. INTRODUCTION

In order to maintain an electrical component in its perfect condition, temperature check is a must. Keeping the components in their perfect working condition enhances the output and reduces the risk of damage. Heat Pipe is a passive technique used in almost every electrical devices be it computers, industrial machines or any other digital screens. For the past decade, these used conventional fluids like water (H_2O), Ethylene Glycol or Methanol as the working medium. But after growth in the Nano technology sector. The conventional fluids are being replaced by Nano Fluids. These have produced great results in the enhancement of heat transfer from one place to another.

2. THEORY

2.1 Principal of operation

Heat Pipe is a closed evaporator-condenser system with a hollow tube, sealed in vacuum whose inside walls are covered in linings or wicks or capillary structure. Thermodynamic working fluid with substantial vapor pressure in optimum conditions saturates the liquid inthe pores. This liquid takes up the heat and evaporates under the low pressure of the pipe. This liquid gets removed from the wick of the walls and comes to the hollow center of the heat pipe and gets diffused throughout the length. This vapor starts condensing at the part where the temperature is even slightly below the saturation temperature.The heat is given up as soon as the vapor starts condensing. The condensed fluid is sent back to the evaporator by the capillary action of the wick structure. A closed loop cycle is completed and it helps in maintaining a near constant temperature throughout the structure.

2.2 Nano fluid

Nano fluids are nanoscale colloidal suspensions containing condensed nanomaterials. These are two-phase systems with one solid phase in another liquid phase. Nano fluids are found to possess enhanced thermal and physical properties such as thermal conductance, thermal diffusion efficiency, viscosity factor, and convective heat transfer coefficients compared to those of base fluids like oil or water.

Table -1: Fluid properties

Water		Silver Nano fluid	
Thermal conductivity	0.609W/m-K	Thermal conductivity	429 W/m-K
Density	997kg/m^3	Density	1040 kg/m^3
Heat of vaporization	40.65kJ/mol	Heat of vaporization	254 kJ/mol

2.3 Heat pipe model

The design of the heat pipe is made as a coiled structure with condenser region extending from the top and reconnecting at the bottom. The coiled part is termed as the evaporator region and the extended longer part is condenser along with adiabatic section in between the two at the top.
The material of the heat pipe is chosen to be Copper (Cu) due to its properties such as good thermal conductivity, ease of access, ductility, ease of fabrication.

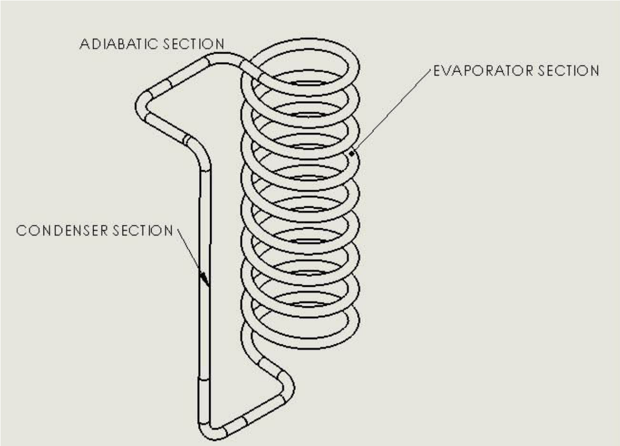

Fig -1: Figure

Table -2: Heat pipe properties

Material	Copper (Cu)
Tube diameter	2mm
Inner coil diameter	18mm
Mean coil diameter	20mm
Evaporator height	65mm
Condenser length	75mm

The designing of the heat pipe shown in Fig. 1 has been carried out in Solidworks 2018. Model was assembled in 3 parts to reduce the error and increase curvature correction. 3D sketch methodology had to be implied to design the heat pipe.

2.4 Analysis and Results

The numerical study both meshing and solving has been carried out in Ansys 18.1. A comparative numerical study has been done on the thermal behavior of the Heat Pipe functioning using water as the conventional fluid and Silver based Nano fluids.
The silver Nano fluid is prepared by one step method using silver Nano particles and based fluid as Ethylene Glycol and water. The surfactant used is Sodium dodecyl benzoic sulfate which increases the stabilization.

The geometry was divided into 3 sections in the design modeler after which a mesh with sizing medium and coarse quality was generated.

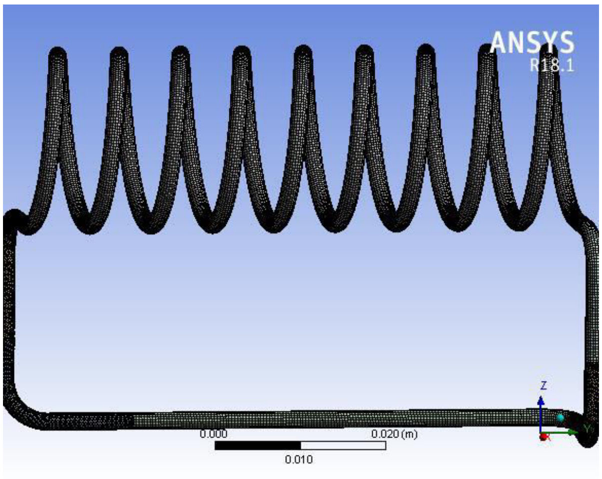

Fig-2:Mesh report

We go with transient state analysis. When the heat pipe reaches its operational range, its initial thermal conductivity could be low due to the freeze out of the working fluid which eventually comes into action.
Multiphase model has been chosen to develop the equation in which euleurian fluid value was kept as three. Due to three mediums i.e. water-vapor, water-liquid and air. Since, we need to work with the temperature for the solution, energy equation is ON and k-epsilon turbulence model is chosen.
The saturation temperature for both the fluids was kept 320K i.e. the temperature at which the fluids are supposed to change phase/boil.

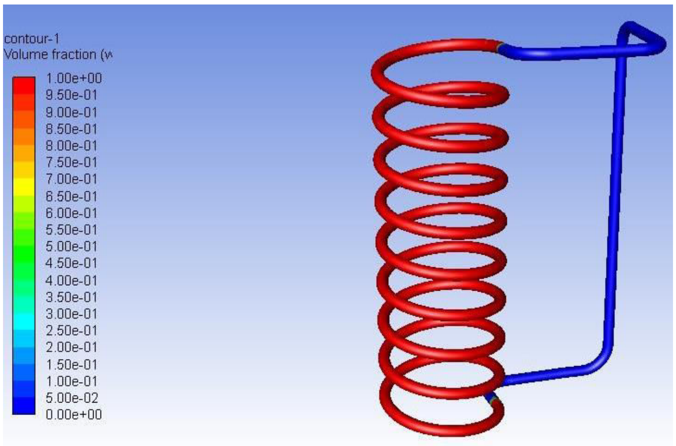

Fig -3: Water volume fraction at t=0 sec.

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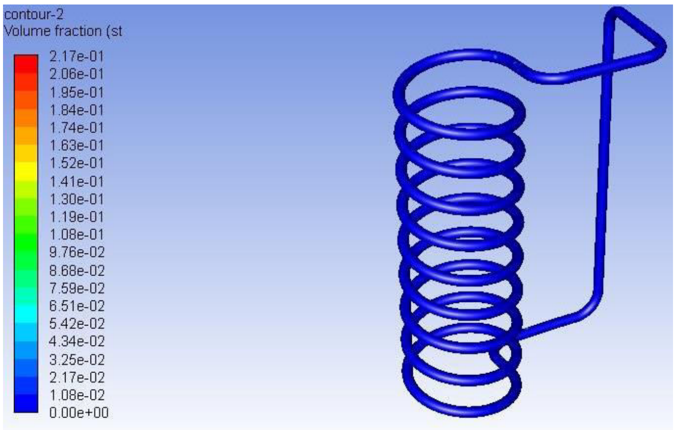

Fig -4: Steam volume fraction at t = 0 sec.

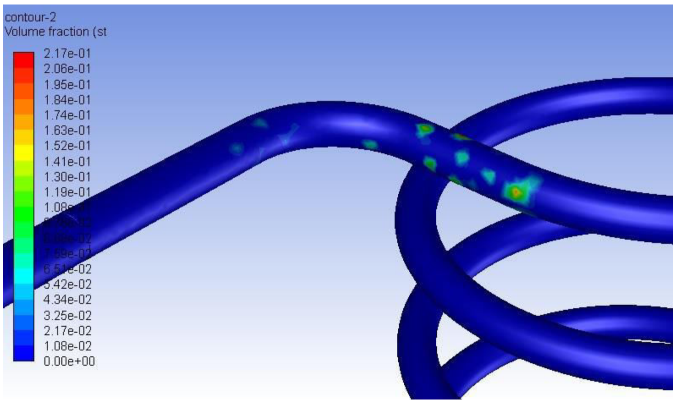

Fig -5: Steam volume fraction at t = 0.256 seconds

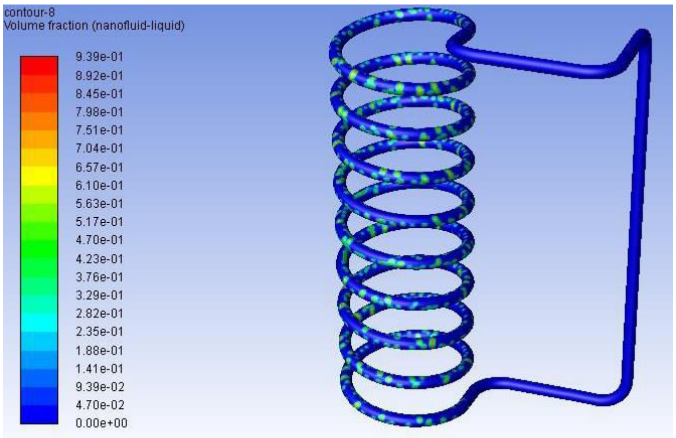

Fig -6: Nano fluid volume fraction patches

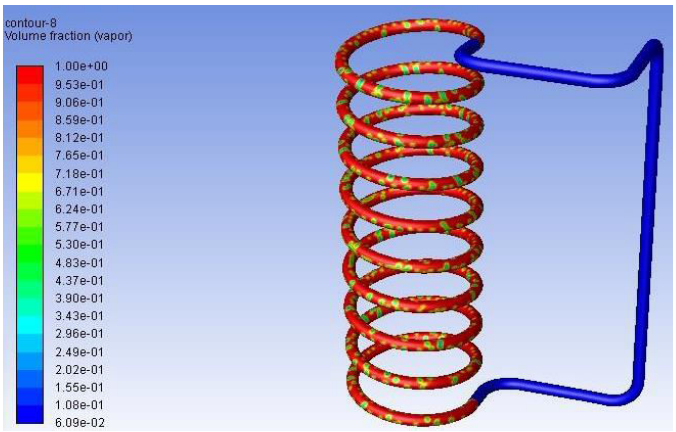

Fig -7: Vapor fraction of Nano fluid

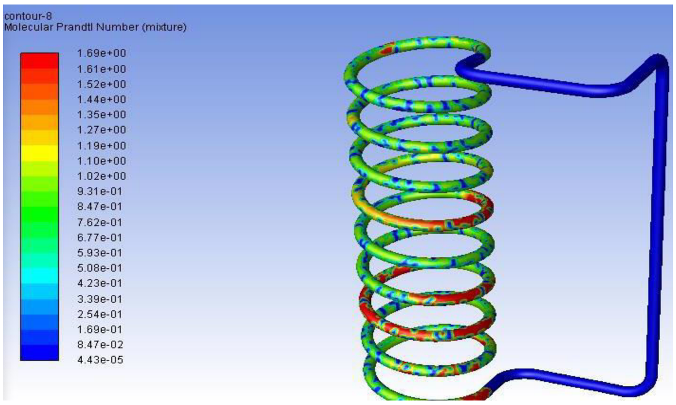

Fig -8: Plot of Prandtl number with time

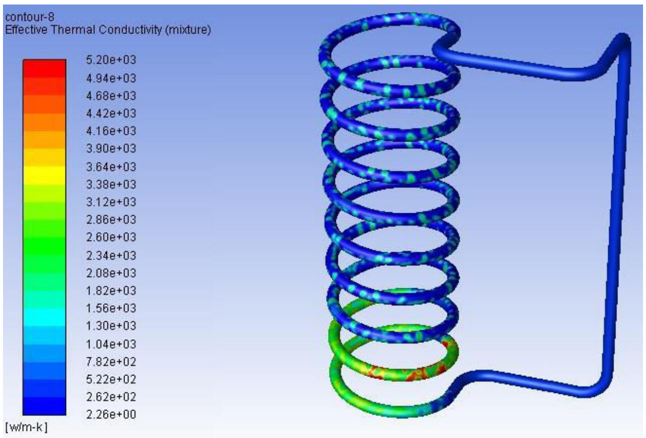

Fig -9: Effective thermal conductivity

The comparative study between the water and silver/EG-H_20 reflects that the Nano fluids develop better properties and have a higher response time. As seen, the water patches took long enough to boil at saturation temperature but the time taken by the Nano fluids was very less. The Prandtl numbers value contour plot gives the information about its rate of heat transfer.The thermal conductivity contours are seen increasing with time.

3. CONCLUSIONS

From the inferred results and data, it is clear that the Nano fluids have a better tendency to perform in a stimulus generated condition.

1. They have a wide range of operating temperatures.
2. An increase in the concentration of the Nano particles will result into a greater heat transfer.
3. Nano fluids are having better response time and thermal conductivity than the conventional fluids.

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