B. TECH. PROJECT REPORT

On

Behavior of Vapor Chamber under transient Heat Flux Conditions

BY

Bipin Kumar

DISCIPLINE OF MECHANICAL ENGINEERING

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Behavior of Vapor Chamber under Heat Flux Conditions

A PROJECT REPORT

Submitted in partial fulfillment of the requirements for the award of the degrees

of
BACHELOR OF TECHNOLOGY
in

MECHANICAL ENGINEERING

Submitted by:
Bipin Kumar

Guided by:
Dr Ankur Miglani, Assistant Professor, IIT Indore

INDIAN INSTITUTE OF TECHNOLOGY INDORE
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CANDIDATE'S DECLARATION

We hereby declare that the project entitled **"Behavior of Vapor Chamber under Transient Heat Flux Conditions"** submitted in partial fulfillment for the award of the degree of Bachelor of Technology in 'Mechanical Engineering' completed under the supervision of **Dr Ankur Miglani, Assistant Professor, Department of Mechanical Engineering,** IIT Indore is an authentic work.

Further, I/we declare that I/we have not submitted this work for the award of any other degree elsewhere.

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Preface

This report on “Behavior of Vapor Chamber under Transient Heat Flux Conditions " is prepared under the guidance of Dr Ankur Miglani, Assistant Professor, IIT Indore. Through this report, I have tried to do the indirect analysis of vapor chamber by doing the direct analysis of copper spreader and comparing it with vapor chamber. While my work was focused on indirect analysis, more work can be done on comparison of copper spreader and vapor chamber in future.

I have tried to do the best of my abilities in this work. I have tried to keep the language simple and understandable and also used the graph and images wherever the need was felt.

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Acknowledgements

I wish to thank **Dr. Ankur Miglani** for his kind support, expertise and valuable guidance. He provided a perfect environment for critical thinking and research acumen and was always available for discussions, doubt clearance and guidance at every part of the project. He has constantly motivated me to take the project to its very culmination.

I would also like to thanks my Teaching Assistants and batchmates for their support and sincere cooperation. It is with their help, due to which I was able to complete the second phase of my project involving Ansys Simulation. They were always available for discussion and doubt clearance.

Without their support, this report would not have been possible.

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Abstract

We are living in a technology driven world today and scientists are already able to fit the whole world in our pocket. Yes, I am talking about mobile phones. And they are trying to make it even smaller. But problem with these electronic devices like smartphones, laptops etc is that the more and more complex we are trying to make them, the more issue of heat problems we have to deal with. There is a lot of heat generation from a small heat source size.

So, we are trying to keep the temperature as much in control as we can. For this, 2-dimensional heat spreading device, popularly known as vapor chamber is popular. A vapor chamber is a 2-dimensional device which also has a wick attached to its inner walls which is made up of porous material. The amount of heat which can be transferred by vapor chamber depends on several factors such as its and heat sink's surface area, wick properties and working fluid.

Our focus will be on working of vapor chambers in high heat flux conditions and we will be doing this indirect analysis of vapor chamber using software Ansys which we will use to do the direct analysis of copper spreader. We will change different parameters to see their effect on copper spreader and will use it to predict the performance of vapor chamber.

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1. Introduction

1.1 Thermal Management of Electronic Systems

The word thermal management incorporates the technology of the propagation, governing and dissipation of heat generated in electronic systems. Heat is an ineluctable by-product of each device and is typically considered a detrimental to performance and reliability. The entire amount of heat as an output is equal in the value of power input if no other energy interactions occur [1].

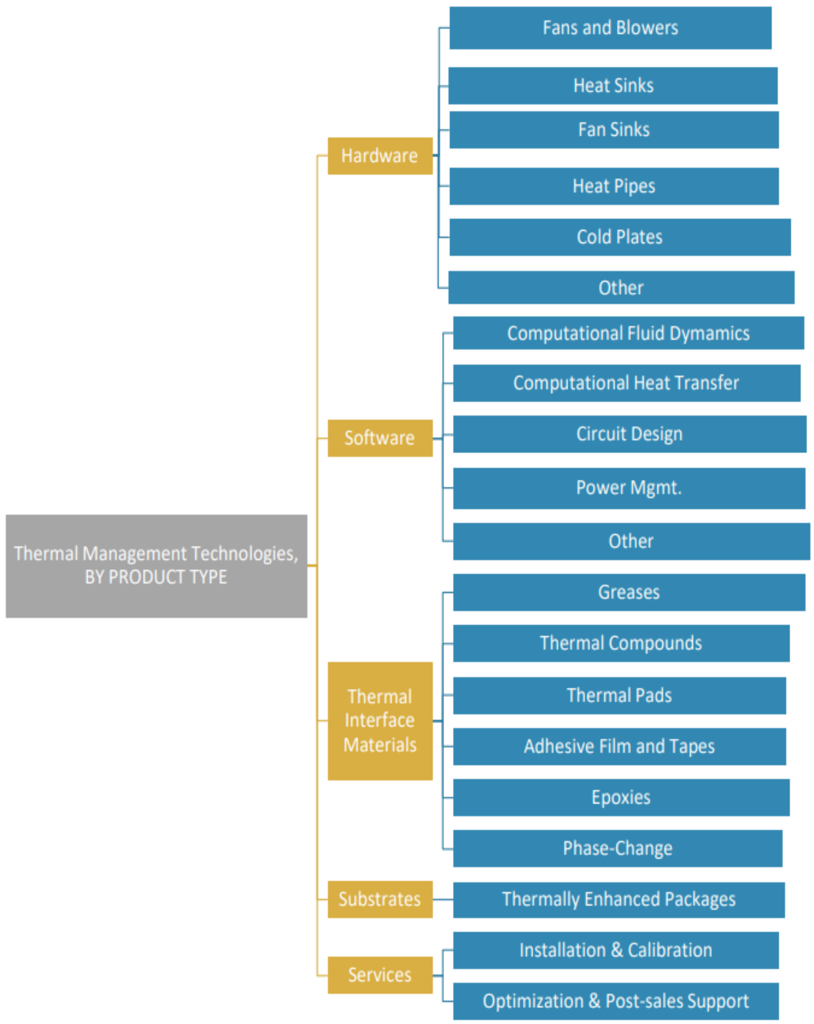

Fig 1: Thermal Management Technologies by Product Type [3]

Various practical methodologies and techniques are available for cooling which includes different varieties of heat sinks, thermoelectric coolers, forced air systems and fans, heat pipes, and others. In cases where environmental temperature is very low, it might be essential that electronic components be heated so that operation can perform [2].

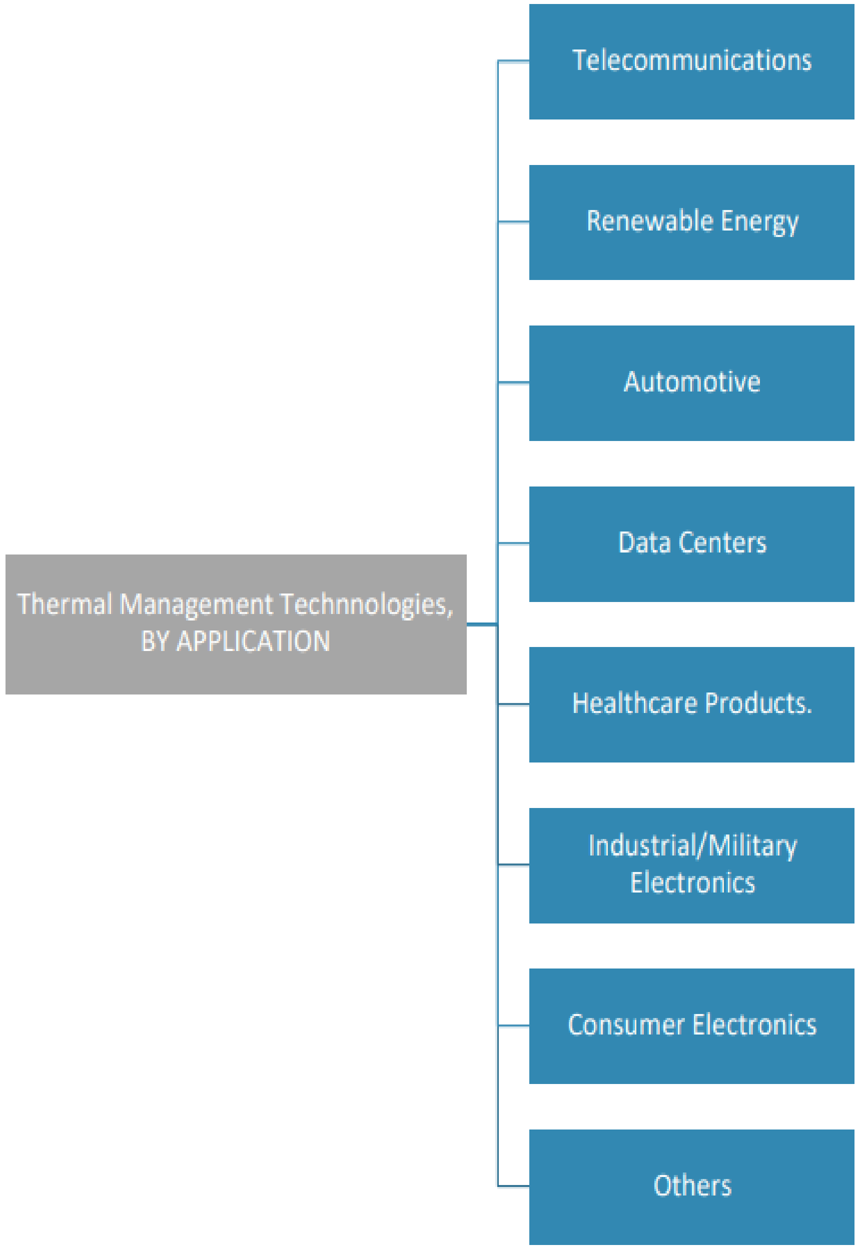

Fig 2: Thermal Management Technologies by Application [3]

A BCC report highlights that the global market for thermal management technologies should grow from $14.5 billion in 2021 to $20.9 billion by 2026 with a compound annual growth rate (CAGR) of 7.6% for the period of 2021-2026. Computer Industry is leading market in world and is still increasing at a rapid pace. With these statistics, need for thermal management of electronic devices will only increase [3].

1.2 Electronic Packaging

Electronic packaging could be a discipline of important importance within the sphere of electronic engineering, and incorporates an intensive range of technologies. It relates the enclosures and preventive features built into the product itself in spite to shipping containers. it's capable to being applied to finish products likewise on the components.

Packaging of an electronic system must encompass protection from mechanical damage, noise emission frequency electrostatic discharge protection, maintenance, operator convenience, and cost. Prototypes and industrial equipment manufactured in small quantities should use commercially available enclosures as per standard and regulation like card cages or prefabricated boxes. Mass-market consumer devices should be provided highly specialized packaging to extend consumer appeal. the identical electronic system could also be adapted for firmly mounting in an instrument rack or packaged as a conveyable device. Packaging for aerospace, marine, or military systems provides non- identical standard.

1.2.1 Hierarchy in Electronic Packaging

The packaging and inter-connection levels have been described as follows:

- Level 0 – Silicon die has connections which connects gates to each other
- Level 1 – Chip is connected to its package
- Level 2 – PCB, component is connected to component or to external connector
- Level 3 – Two PCBs are connected which may also includes motherboards.
- Level 4 – Two subassemblies are connected
- Level 5 – Physically distant objects are connected, e.g. LAN

1.3 Vapor Chamber

Electronic systems in recent years became smaller in size but due to their high-performance requirements, the problem of heat dissipation has increased many folds. This heat, if not removed properly can cause heating of the adjacent components. Therefore, a correct cooling solution is required. The property of thermal conductance obtainable by heat pipes and vapor chamber devices (Two-phase liquid as heat transfer medium) has boosted their consumption across many industrial related applications. Main working rule of both heat pipes and vapor chamber revolves around two phase heat transport capabilities of fluids, during which a fluid transports and spreads heat via alternate cycle of vaporization and condensation staying inside a low-pressure barrier. This fluid is primary heat carrier (sometimes called as working fluid) and is sealed as a part of manufacturing process. Figure-3 shows the schematic diagram of vapor chamber [4]. When vapor chamber equipment is close to a heat source, the working fluid will absorb the heat and convert it into vapor which will increase localized vapor pressure. This increase in vapor pressure acts as the driving force, which drives vapor to go to a low-pressure condenser region where it will be converted back to the liquid state. By taking advantage of the very useful phase-change heat transfer mechanism across the

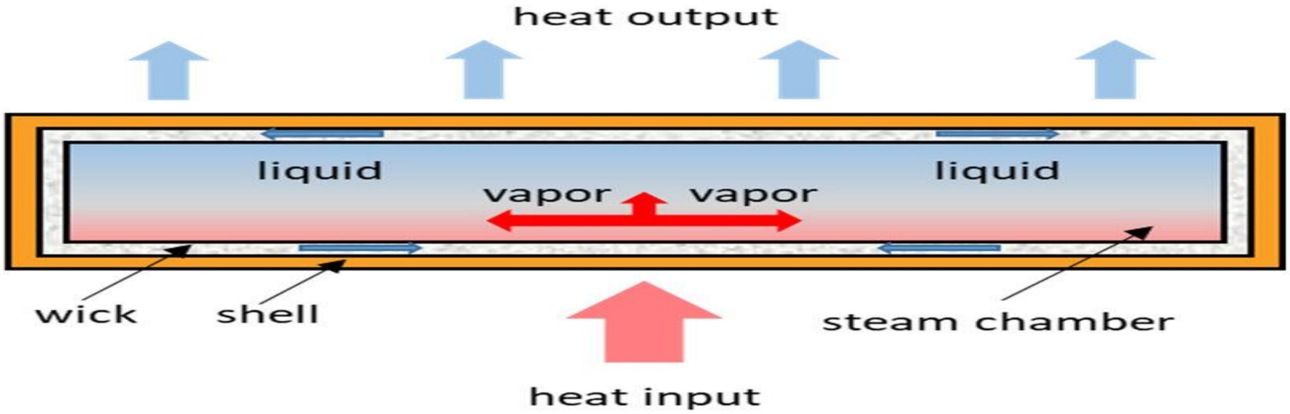

Fig 3: Schematic Diagram of Vapor Chamber

liquid-vapor interfaces, this heat transportation process takes place almost under an isothermal environment at a low saturation pressure variation.

No active power source is required as the process is passive, i.e. transport vapor from evaporator to condenser through pressure difference and also of the condenser to its original position by capillary in the porous wick material. the Capillary pressure, generated by the porosity of the wick material, must prevail when the pressure drops along the vapor and liquid flow paths to continue operating at variable heat transfer rate. When this problem and other operating limitations can overcome the thermal conductivity increased many times compared with the same heat transfer capacity of solid materials of size. These operational constraints include but unrestricted to minimize liquid transport in the vapor stream. The term thermosiphon does not apply to vapor chamber devices because they do not use the force of the gravity to return liquid condensate, it instead uses capillary action in a porous wick material to provide an impetus for the return of working fluid. The most used type of heat pipe setup is a properly sealed tube with porous wick material along the inside of the wall.

When heat is transferred from one region of any material to another, this transfer is always met with resistance by the material. This resistance makes it difficult for heat to be distributed and the surface of the heatsink where the heat source is located faces a high temperature gradient and a hot spot is created. The consideration of resistance to heat flow is essential in design calculations. One way to get around this problem is to use a material with high thermal conductivity (Cu instead of Al). Another way could be to use heat pipes and steam chambers for more efficient heat transfer. With regard to the heat pipes and vapor chambers, the presence of biphasic phenomenon is the main advantage for faster temperature distribution.

The heat resistance of the vapor chamber and heat pipe can be found simply by subtracting the average temperature of the top surface of the baseplate from the temperature of the hottest point on the baseplate and dividing it by the power. Table 1 shows the thermal conductivity values of the heat pipe compared to other materials with the best thermal conductivity values.

Material	**Thermal Conductivity (W/m °C)**
Heat Pipe	50000-200000
Diamond	2000
Copper	386
Aluminum	240

Table 1: Thermal Conductivities of Heat Pipe and Different Materials

Types of heat pipes are available because of their different applications in the industries. Heat pipes without wick for heat transportation over long distances, gaseous heat pipes of controlling specific temperatures and also the heat pipes which use centrifugal force to return the working fluid [5, 6, 7, 8]. Numerous reviews are available to complete recent research on promising heat pipe applications, new working fluid preparations, and modeling techniques [9, 10, 11, 12]. Increasing power density produces more heat, and the need to dissipate this heat at high density is an important issue. This problem requires new technologies to increase thermal conductivity and a robust approach to manufacturing devices. In general, the highest heat transfer capacity and thermal conductivity are controlled by the properties (physical and manufacturing) of the wick material of the cooling device. However, the dimensions of the device are limited because the vapor gap can create a large thermal resistance in small length devices.

1.4 Problem Statement

The electronic industry has emerged very quickly in no time. And it is still the one of the most emerging industries. There is large power dissipation from these electronic devices and they are still getting smaller and more complex. So, the problem of heat dissipation will only increase in future. For this, Vapor Chambers are used. It allows the heat to spread in two dimensions quickly as it has a large surface area as compared to 1-D heat pipe. We will be focusing upon working of vapor chambers and how they dissipate heat and moderate the temperature in electronic devices.

1.5 Aim of the Project

The aim of this project is to do a indirect analysis of vapor chamber under transient heat flux conditions using Ansys. This will be done by doing the indirect analysis of copper spreader and comparing its performance with the vapor chamber based on data and results of previous studies done on the same.

1.6 Objectives of the Project

- Literature Survey of development of heat pipes, copper spreader and vapor chamber over the years.
- Literature Review of the recent advancements in field of vapor chambers.
- Choosing a specific model to evaluate the case study which involves all the materials of the vapor chamber.
- Development of a 3D CAD model of copper spreader in Solidworks/Autocad.
- Import CAD to Ansys workbench to perform simulation.
- Doing steady state thermal analysis of copper spreader model.
- Post processing the results using Ansys.
- Using the results to predict the performance of vapor chamber
- Showing the results and concluding the project.

2. Structure of Vapor Chamber

2.1. Vapor Chamber

Vapor chamber is a vacuum chamber having minimal thickness of walls and it may or may not contains the wick lining on the inside of the walls. This vapor chamber has a working fluid which is water in most cases within that vacuum chamber. The wick is saturated with that fluid. When heat is applied, due to low pressure inside the vapor chamber, the liquid turns to vapor rapidly and it fill the chamber in no time. Whenever this vapor come in contact with condenser side surface, they get condensed, hence releasing the heat in form of Latent heat of vaporization. This process continues as vapor which was turned back to liquid is returned to the evaporation section by capillary action of the wick. The thermal conductivity of vapor is very high compared to solid copper blocks. Vapors also have high latent heat of vaporization and can carry more heat at low temperatures. Moreover, vapors can move freely in any direction so heat spread in all directions is possible and also hot spots can be avoided.

Heat Pipes and Vapor Chambers are different from each other. Because Heat Pipe can transfer heat in one direction only but vapor chamber use phase change mechanism and can spread the heat in two directions. But basic function of both is same, they transfer the heat from the heat source to the heat sink in the electronic devices to control the temperature. Figure 4 shows the working diagram of heat pipe while figure 5 shows the working diagram of vapor chamber.

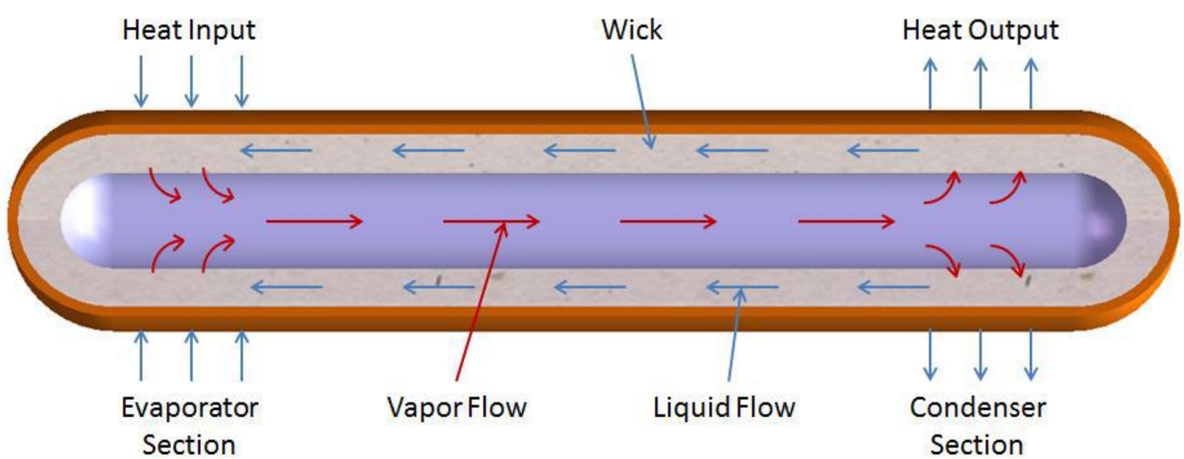

Fig 4: Heat Pipe

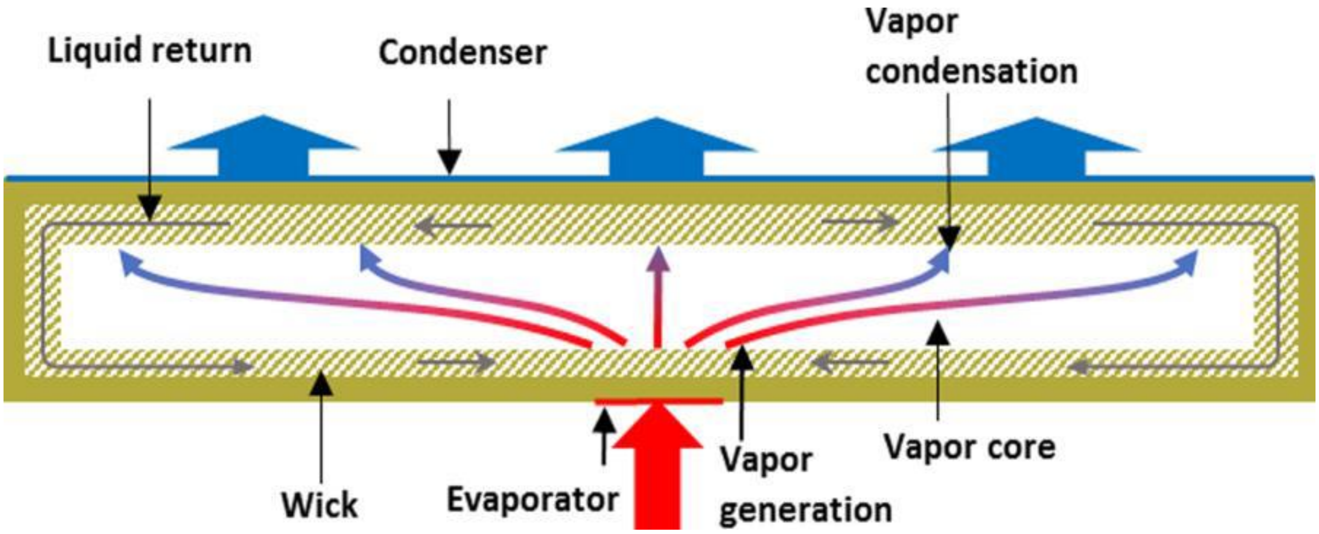

Fig 5: Vapor Chamber

A vapor chamber is used to transfer heat typically from chip which is the power source in electronic devices to the heatsink which is usually made up of copper or aluminum. The vapor chamber is placed on top of the chip and is bonded with Thermal Interface Material (TIM) which is used to avoid air gaps in bonding and also to avoid much of thermal resistance. Two of the main components of vapor chamber which affect its performance to great extent are:

- Wick
- Working Fluid

2.2. Wick

The kind and nature of the wick structure is one of the variables that influence the functioning of a heat pipe/vapor chamber. To enhance the thermal efficiency of these devices, porous structures (wick) with high capillary pressure and permeability while minimising fluid flow resistance are desired. In order to make sure thin-film evaporation, a substantial meniscus area is also required. Different power density handling capabilities, the configuration in which they are operated, and the thermal resistance offered by the wick structure must all be considered when choosing a core structure. Sintered wick, grooved wick, and screen wick are the three most common wick structures.. The figure 6 shows schematic representation of these wick structures [13].

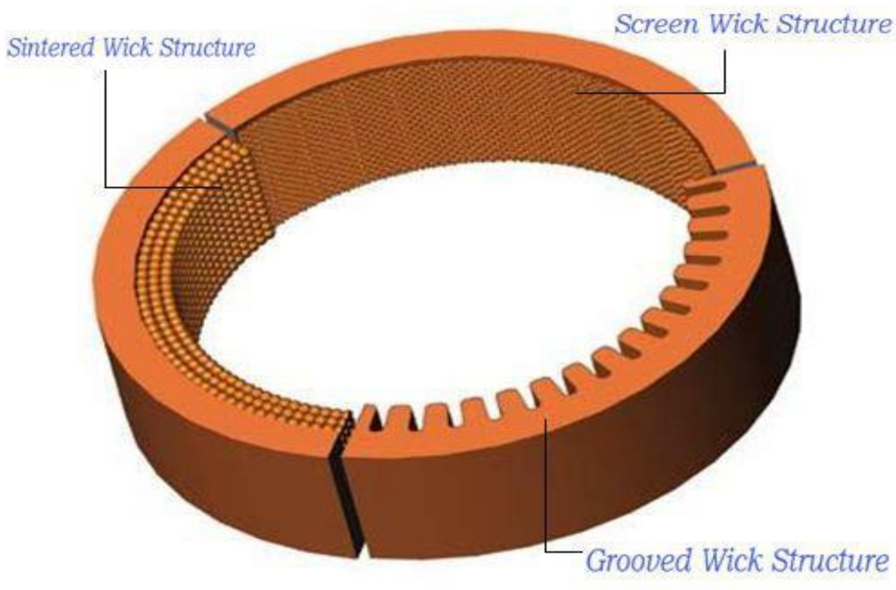

Fig 6: Types of Wick

2.2.1. Screen Wick

The metal is firmly wrapped around the mandrel and put into an aluminum or copper tube, or heat pipe, in this configuration. The mandrel is subsequently withdrawn from the tube, and the wrapped metal is held in place by the tension of the wrapped metal. The wick structure's performance is determined by the material's porosity.

2.2.2. Grooved Wick

When the heat source is above the condenser, this wick is employed. Extrusion or tapping is a technique for making grooves in aluminum or copper tube. The major benefits of utilizing such a design are cost savings and the simplicity with which very tiny cores may be designed.

2.2.3. Sintered Wick

The most prevalent wick structure on the market is sintered wicks. The metal powder is bonded to the inner wall of the tube and hardened in this arrangement [2]. The most prevalent substance for this wick construction is copper powder. Most resistant to gravity and heat source orientation. It is also the most costly wick construction and has the most strong capillarity of the three types.

The wick structure serves the same primary purpose. In other words, it causes the liquid to return from the condenser (heat removal / heat sink) to the evaporator (heat input / source) by capillarity. Without losing performance, the sintered wick design works well in curved geometries. Because there are no bending limits, heat pipes commonly employ a sintered wick construction when heat needs to be delivered from one location to another. The following table shows the various properties of the 3-wick structure.

Wick Type	Power Density	Resistance	Orientation
Sintered Wick	<500 w/cm²	0.16-0.04 °C/w/cm²	+90° to -90°
Grooved Wick	<35 w/cm²	0.26-0.14 °C/w/cm²	+90° to -5°
Screen Wick	<25 w/cm²	0.35-0.23 °C/w/cm²	+90° to 0°

Table 2: Properties of Different types of Wick Structures

2.3. Working Fluid

A vapor chamber is a two-phase device that uses a working fluid to transfer heat. By changing its phase from liquid to vapor and back to liquid, this working fluid acts as a heat transmission medium. The working fluid to be used is determined by a number of criteria, including the equipment's operating temperature range, the working fluid's vapour pressure, and the needed latent heat of vaporization for the application. We know that the boiling point of a liquid is the temperature at which its vapor pressure matches its ambient pressure. The vapor pressure can be used to estimate the rate of liquid evaporation. A liquid's boiling point is lower than that of a gas at low pressure. The operating temperature range for commercial electronics is typically 0°C to 70°C. As a result, for vaporization to occur, the hydraulic oil's boiling point must be within this range. The vapor chamber's significant heat production is related to the working medium's high latent heat of vaporization..

Table 3 shows the details of the types of working fluid used in two phase devices [13].

Working Fluid	Boiling Temperature at Atmospheric Pressure (101 kPa)	Boiling pressure (kPa) at saturation temperature (45°C)	Latent Heat of Vaporization (Kj/Kg)
Water	100 °C	9.59	2264.76
Methanol	64.7 °C	44.47	1104
Acetone	56 °C	67.91	518
Ammonia	-33.34 °C	1578.9	1369

Table 3: Types of Working Fluids used in Two Phase Devices

From the table, It is obvious that the working fluid must have a boiling point within the electronic device's operational temperature range. Reduce pressures have been discovered to lower the boiling point of a liquid. The boiling point of the liquid is substantially lower than atmospheric pressure due to the vacuum inside the vapour chamber. For our application, we chose water as the finest working fluid. Water has a vapour pressure of 9.59 kPa at 45 ° C in the heat spreader zone of our model, which falls into the lower vacuum region. It also has a high latent heat of vaporisation of 2264.76 KJ/KG, which means it has excellent thermal performance.

In addition to the above features, the following considerations play an important role in the working fluid selection. Excellent thermal stability, wick and wall material wettability, high surface tension, high latent heat, low liquid and vapour viscosities, and high thermal conductivity are among the characteristics stated.

3. Literature Review

The overall performance of the heat pipe and vapor chamber is usually based on heat transfer capacity and temperature distribution efficiency. This overall performance can be calculated and investigated with the use of Computational Fluid Dynamics (CFD) software. CFD evaluation has additive benefits of much less price and time-saving over the use of an experimental setup. For this purpose, a literature survey was done to get an idea of formerly finished research in this field.

S. Sudhakar et al. [15] did the study of enhanced thermal performance of a heat assembly having two layers wick structure cooled by air. Sintering copper particles onto a copper substrate produces single-layer and double-layer evaporator wick architectures. A commercial assembly technique is then used to seal the copper substrate into a vapor chamber. On the evaporator side of the sealed and charged vapor chambers, a serpentine resistive heater is directly constructed. A graphite thermal interface material is then used to connect the vapor chambers to a pin-fin heat sink. An air-jet impingement facility is used to assess thermal performance. When compared to the monolayer wick vapor chamber, the two-layer wick vapor chamber has a significant reduction (12%) in total thermal resistance of the assembly (which includes the fixed heat sink and interface thermal resistances). The dry out heat flux of the two-layer wick vapor chamber is 451 W/cm2 (at a heater temperature increase of 154 K above the heat sink air intake), whereas the monolayer is 513 W/cm2 (at a temperature rise of 198 K). This equates to a total thermal resistance of 0.34 K/W for the heat sink assembly with a two-layer vapor chamber wick and 0.38 K/W for the heat sink assembly with a monolayer vapor chamber wick, respectively. More work is needed to increase the two-layer wick's maximum dryout heat flow while keeping the low thermal resistance advantage. Air-cooling employing vapor chambers with two-layer evaporator wicks is practical for next-generation electronics for thermal management of high-power density, high-temperature capable WBG semiconductors.

Modak et al. [13] proved that the two-phase devices exhibit superior thermal performance over solid metal heat spreaders for the current application. The CFD analysis of vapor chamber showed lesser thermal resistance than that of copper heat spreader model. On comparison it was observed that for smaller sizes, the thermal performance of both heat spreader and vapor chamber were comparable but with the size being more than about 30mm×30mm, there was a trend that vapor chamber was more efficient for that model and size and there was an average difference of 5°C with very less variation between the temperatures of vapor chamber and copper spreader model.

S V Garimella et al. [14] developed the three-dimensional model to predict the performance of two-phase heat spreaders such as heat pipes and vapor chamber which use water as working fluid which is main cooling medium. They used the model to simulate 3-mm thick vapor chamber. The model was validated by comparing it with the experimental data. They noted that vapor chamber is a better heat spreader than normal metal blocks i.e. copper spreaders only at higher heat fluxes (>100W/cm²) for the same geometry and given temperatures. Nucleate boiling also occurs at these temperatures which help to reduce the thermal resistance in vapor chamber. The pillars which connect the two wick layers helps in decreasing the path for return of water to great extent and decrease the liquid flow pressure drop by considerable amount. This model hence confirms that vapor chamber are excellent heat spreaders for heat fluxes greater than 100 W/cm².

R thangaivelan et al. [16] did the experimental study to investigate the effect of microfin height and spacing in convective heat transfer coefficient of heat sink. This study was done under steady state natural convection conditions. This study confirms that copper shows the maximum convective heat transfer rate compared to Aluminum and Stainless Steel. The convective heat transfer rate of copper was almost 50% higher than that of Aluminum. The performance of stainless steel showed no improvement when changing the spacing between fins. Copper is most preferred element while Aluminum can be considered when mass of micro fins is in play.

4. Methodology and Work Plan

4.1. Work Plan

First the review of previous literature work on vapor chamber and copper spreader comparison was done and the data on copper spreader simulation was collected from previous studies done in the field. Then the similar copper model was designed and simulation was performed on the same and data was compared to previous studies to validate the simulation. There was error in the simulation which was validated. This error was due to geometry simplification which was done to avoid complications in designing the model. This error was noted down.

A new three-dimensional model was designed which was similar to the design of vapor chamber with which we are going to compare the performance of copper spreader. The thickness of vapor chamber and copper spreader was kept same to avoid complications. The lateral size was kept greater than 30mm × 30mm because when the size is less than this, performance of both vapor chamber and copper spreader is almost the same.

This developed model was then simulated using Ansys. The data was noted and was used to predict the performance of vapor chamber. Various parameters were also changed to see their effect on the performance of heat spreader devices.

4.2. Design Used

The design of two-layer wick vapor chamber was selected to compare with copper spreader. This design was selected because based on literature review, this is the most optimized design of vapor chamber. Two layers of wick are connected by micro posts. These posts help in easy returning of the working fluid which help in reducing the pressure drop due to liquid flow. This also provide low thermal resistance compared to monolayer wick. Figure 7 shows the design of vapor chamber with which we are comparing our copper spreader model and Figure 8 is showing the model of copper spreader used for the simulation. Table 4 shows the thickness of parts of vapor chamber.

Part of Vapor Chamber	Thickness(mm)
Lower Wall	1
Lower Wick	1.5
Micro Posts/ Vapor Space	0.5
Upper Wick	1
Upper Wall	1

Table 4: Thickness of vapor Chamber Parts

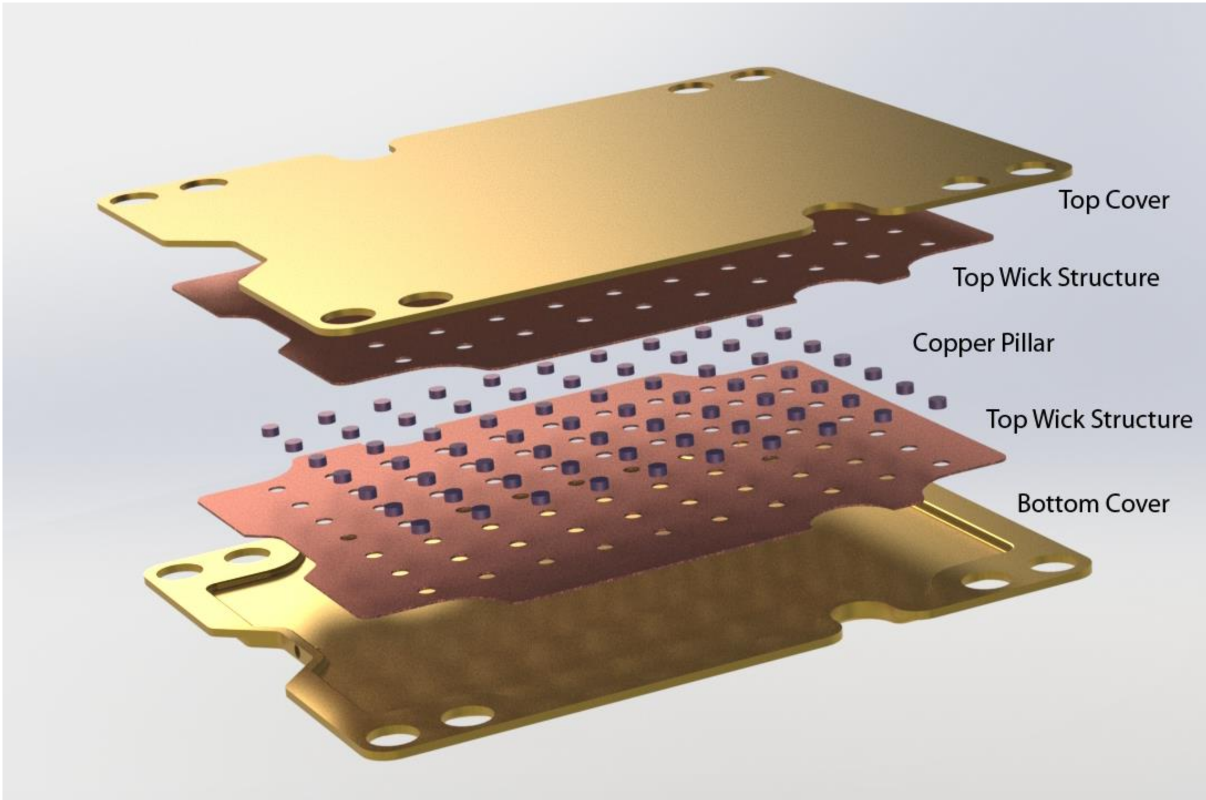

Fig 7: Design of Vapor Chamber

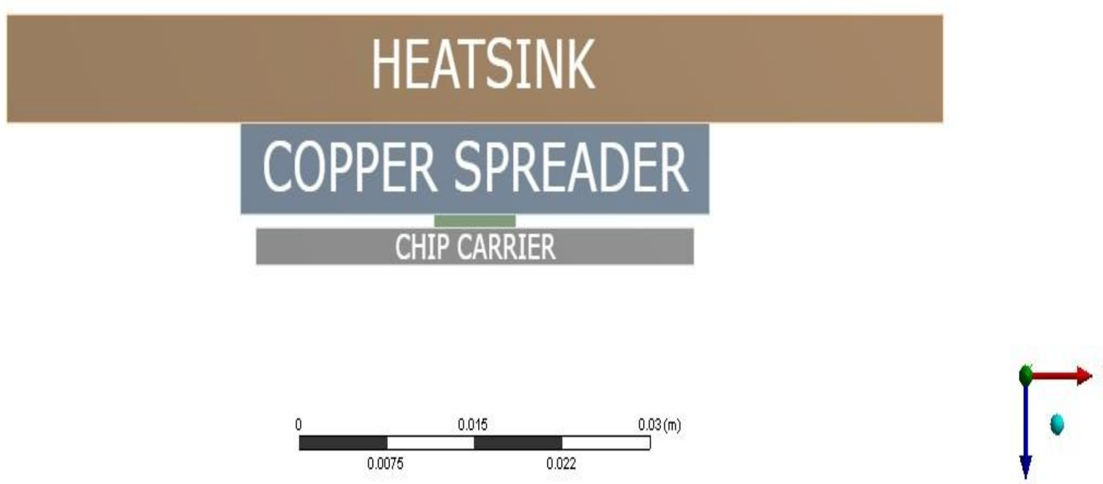

Fig 8: Model of Copper Spreader (Unnamed part is chip)

4.3. Simulation Details

- Software Used: Ansys
- Meshing Type: Automatic
- Element Size: 0.75 mm (except 0.39mm for chip)
- Time Variation: Steady State
- Ambient Temperature: 35°C
- Default Convective Thermal Coefficient: 1400 W/m²K
- Default Power Input: 100 W
- Default Size:
  - Heatsink: 80mm × 80mm × 6mm
  - Copper Spreader: 40mm × 40mm × 5mm
  - Chip: 7mm × 7mm × 0.785mm
  - Chip Carrier: 37.5mm × 37.5mm × 2mm
- Material Used:
  - Heatsink: Aluminum
  - Copper Spreader: Copper
  - Chip: Silicon
  - Chip Carrier: Ceramic Material
- Variables Calculated:
  - Junction Temperature: Temperature at top surface of chip
  - Case Temperature: Temperature at top surface of cooling device

All the materials used was built-in available in Ansys with defined properties. Element size and meshing type was selected after trying various options and balance between high computational time and good solution was maintained.

5. Parametric Study

We changed the various parameters in the model while keeping the other parameters constant to analyse their affect on the performance of copper spreader and then used the same to predict the performance of vapor chamber.

5.1. Effect of Change in Heat Spreader Size

The heat spreader size is varied for copper spreader and its performance was analyzed. Heat spreader is a square block of 40mm × 40mm. Its size was varied by changing the size of square block in step of 10mm. Junction temperature and case temperature were noted down for the given size and was used to predict the performance of vapor chamber. It can be seen that both junction temperature and case temperature decrease as we increase the heat spreader size. Figure 9 shows the effect of change in heat spreader size.

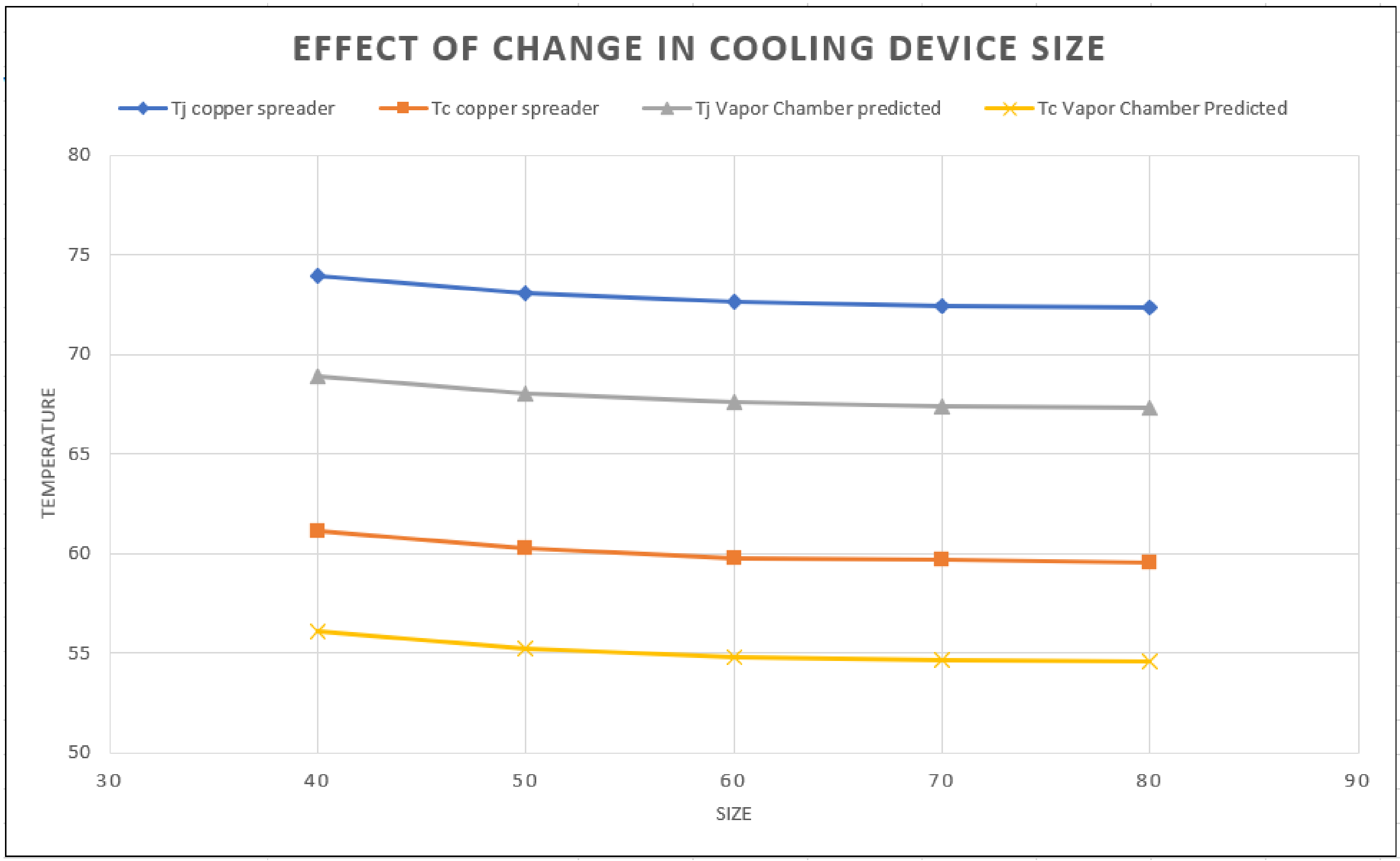

Fig 9: Effect of Change in Cooling Device Size

5.2. Effect of Change in Heat Sink Size

The heat sink size is varied for copper spreader and its performance was analyzed. Heat sink is a square block of 80mm × 80mm. Its size was varied by changing the size of square block in step of 10mm. Junction temperature and case temperature were noted down for the given size and was used to predict the performance of vapor chamber. It can be seen that both junction temperature and case temperature decrease as we increase the heat sink size. Figure 10 shows the effect of change in heat sink size.

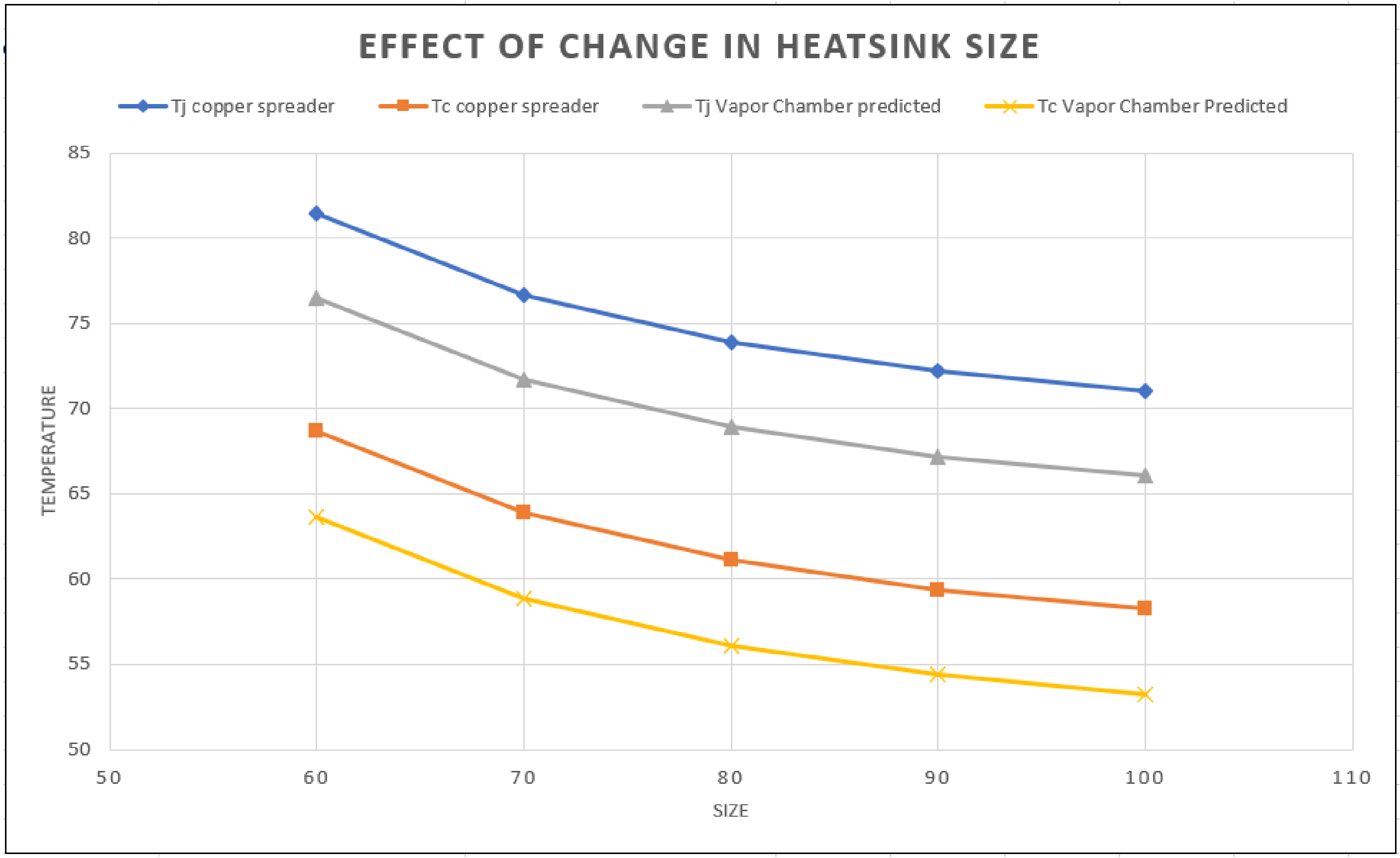

Fig 10: Effect of change in Heat Sink size

5.3. Effect of Change in Convective Thermal Coefficient

The convective thermal coefficient is varied for copper spreader and its performance was analyzed. Default value of convective thermal coefficient was set at 1400 W/m²K. It was varied by changing in step of 1000 W/m²K. Junction temperature and case temperature were noted down for the given coefficient and was used to predict the performance of vapor chamber. It can be seen that both junction temperature and case temperature decrease as we increase the convective thermal coefficient. Figure 11 shows the effect of change in convective thermal coefficient.

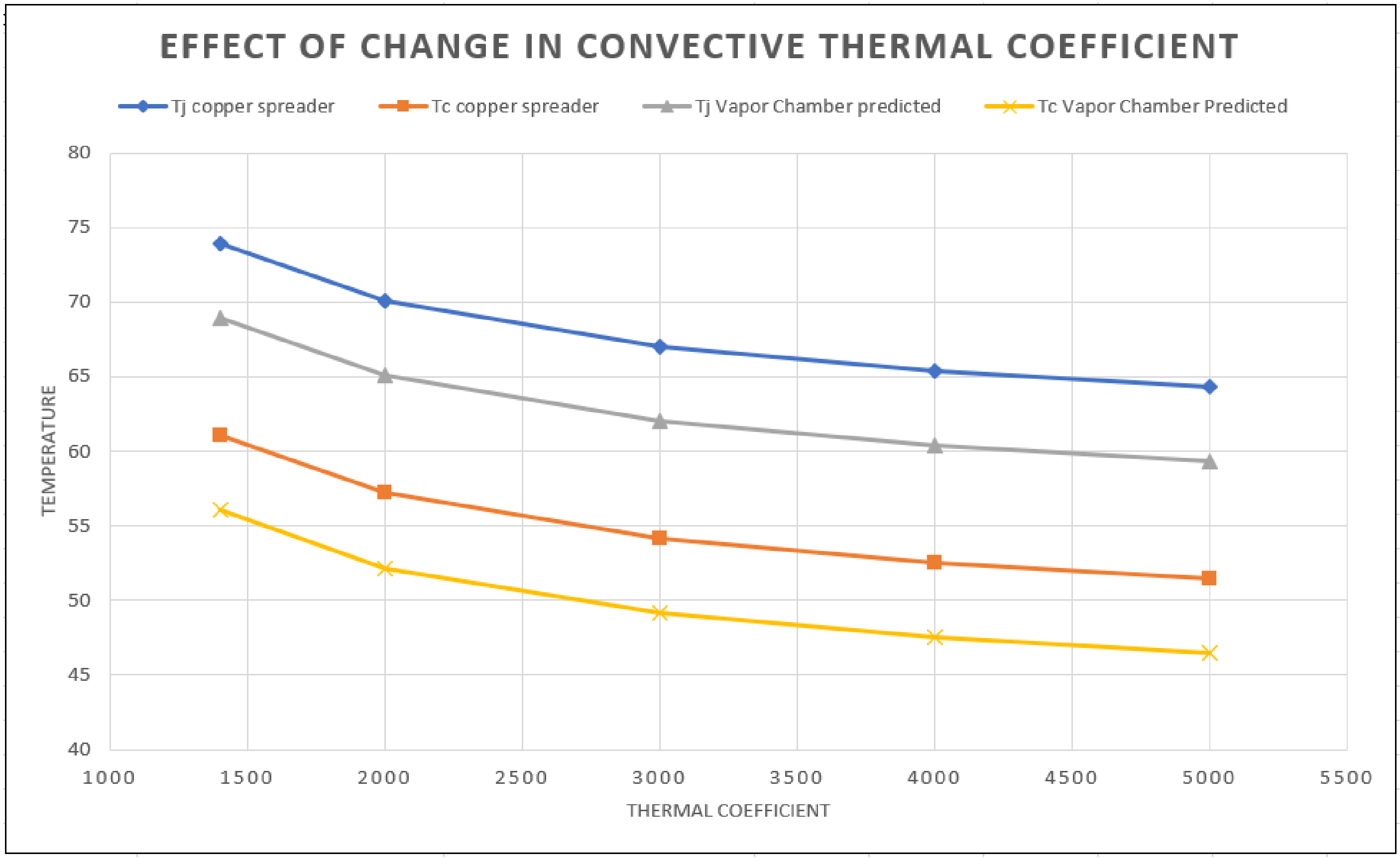

Fig 11: Effect of Change in Convective Thermal Coefficient

5.4. Effect of Change in Power Input

The power input is varied for copper spreader and its performance was analyzed. Default value of power input was set at 100W. It was varied by changing in step of 50 W. Junction temperature and case temperature were noted down for the given power input. It is not used to predict the performance of vapor chamber because unlike other properties where both vapor chamber and copper spreader behave more or less same, vapor chamber and copper spreader behaves differently when we change the power input. It can be seen that both junction temperature and case temperature increase as we increase the power input. Figure 11 shows the effect of change in power input.

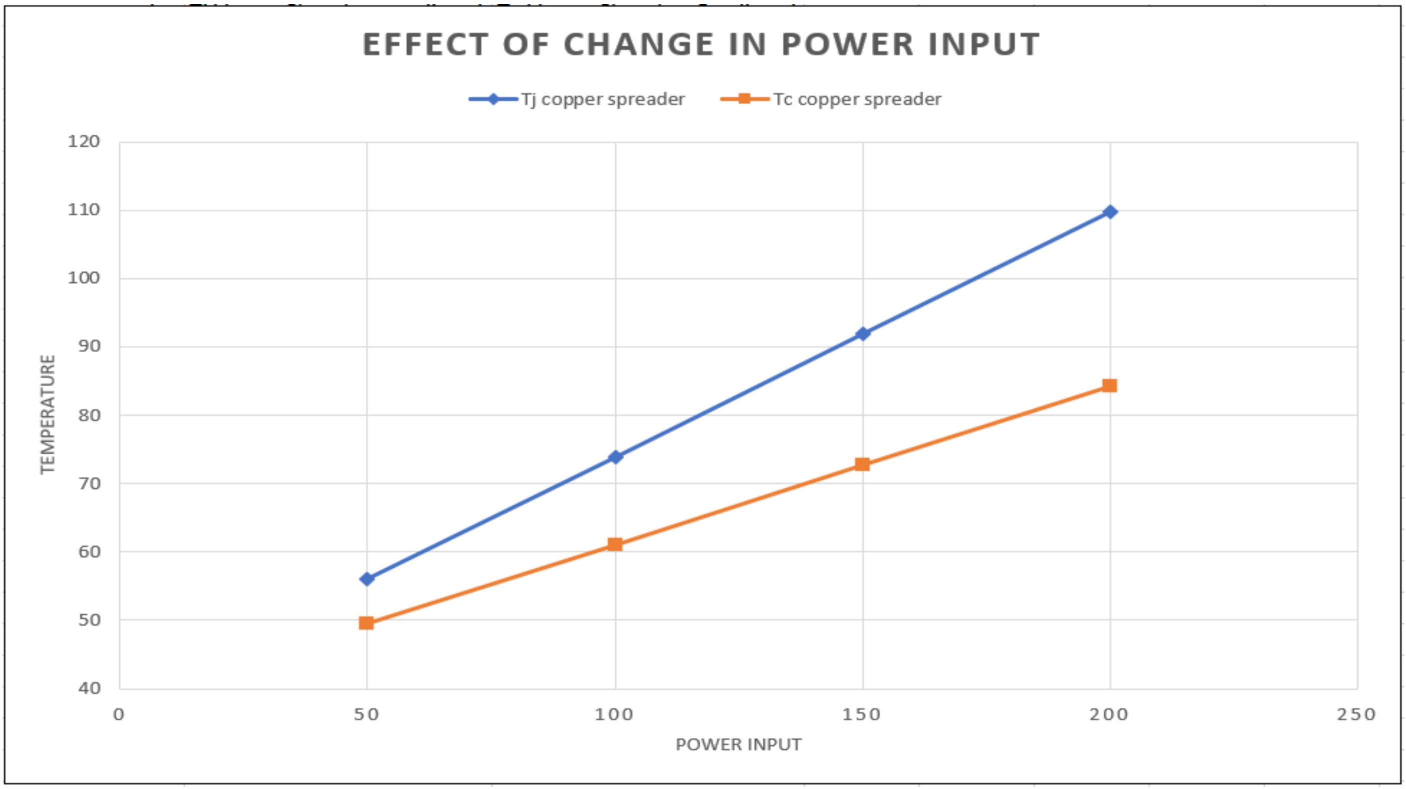

Fig 12: Effect of Change in Power Input

6. Conclusion

6.1. Summary

Copper Spreader and Vapor Chamber are heat spreading devices which are used in electronic devices to control the temperature at the source. This study was done to simulate the model of copper spreader and using it to predict the performance of vapor chamber. Parametric study was done to analyze the effect of changing various parameters on these devices. We concluded that:

- When we increase the size of heat spreader (cooling device), both the junction temperature and case temperature decreases. This is because of the increase in surface area of cooling device which results in increase of heat transfer to heat sink.
- When we increase the size of heat sink, both the junction temperature and case temperature decreases. This is because of the increase in surface area of heat sink which results in increase of heat transfer to surrounding.
- When we increase the convective thermal coefficient, both the junction temperature and case temperature decreases.
- When we increase the power input, both the junction temperature and case temperature increases. We also noted that the difference between the case temperature and junction temperature also increase when we increase the power input. This is because when we increase power input, the efficiency of copper spreader decreases and it is unable to transfer all the heat from chip to heatsink and thus temperature difference increase.

6.2. Future Work

- The result of this simulation can be compared with the experimental data and the degree of accuracy can be calculated. This will help in determining the deviations if any and also to understand the reasons for the same.
- More analysis and experiments need to be done on specific parts of vapor chamber as it is still an unexplored field. There is also need to do extensive simulation of two-phase model as very few researches have been done on the same.
- Behavior and properties of wick need to be studied more, particularly its porosity, thermal conductivity and capillary limit as it is the most complicate part while doing the direct analysis of vapor chamber.

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