International Journal of Trend in Scientific Research and Development (IJTSRD)
International Open Access Journal | www.ijtsrd.com
ISSN No: 2456 - 6470 | Volume - 3 | Issue – 1 | Nov – Dec 2018

Design and Analysis of Liquid Cooled Cold Plates using CAD Modeling

Pratik N. Raut[1], Prof. Mahendra P. Nawathe[2]
[1]PG Student, [2]Associate Professor
Department of Mechanical Engineering,
Prof. Ram Meghe Institute of Engineering & Technology, Badnera, Maharashtra, India

ABSTRACT
For cooling electronic systems new techniques are invented. Cold plate is liquid cooling system used in electronic components. In present work, the modification is done in design of cold plate to reduce its cost and also to increase the heat dissipation rate. Water at various flow rates is supplied for given power inputs and heat removing capacity of each flow rate at that particular heat load is calculated. It is found that water is best working fluid for all flow rates. Methanol and acetone are best suited for high mass flow rates. The cold plate is used to provide a “cold wall” to which individual electronic components are mounted. The design and performance evaluation of a cold plate follows a prescribed procedure that depends on the heat loading and whether the heat loading is on one or two sides of the cold plate. Due to transmission of applied current and voltage sometimes the temperature of the circuit plate goes increasing. This temperature limits the electronic operation. Thus it is necessary to control such temperature, in order to maintain speed of electronic devices.

KEYWORDS: *Liquid Cooling, Cold Plates, Temperature, Heat Transfer, Electronic Application*

1. INTRODUCTION
In heavy electronic equipped industries, high temperatures are attained in working conditions. The safe temperature limit for the electronic equipment’s 90°C. This raise in temperature will take an adverse effect on the equipment’s and sometimes fails at these conditions. This is due to the electronic equipment’s life time will be reduced. So the equipment maintain safe temperature condition which is below 90°C, maintain the desired condition liquid cooling is provide effectively. Liquid cooling is a convective heat transfer process.

The cold plates are classified as follows:
1. Formed Tube Cold Plate (FTCP)
2. Deep Drilled Cold Plate (DDCP)
3. Machined channel Cold Plate (MCCP)

Form tube liquid cold plates ensure minimum thermal resistance between the device and the cold plate by placing the coolant tube in direct contact with the device base plate. In this design, copper plate is generally used, although aluminum is sometimes employed in low power applications. In Deep drilled cold plate the heat flux and power dissipation increases, the contact resistance of the plate and the tube wall become unacceptably high. In this design, deep holes are drilled in the plane of the substrate plate. In Machined channel cooling plate, the heat flux increase, it becomes necessary to improve the thermal performance of the channels. In this design, channels are machine-cut into the base plate and a cover is soldered in place to form the flow passages. In the literature thermal analysis of form tube, machined channel and Deep drill cold plates at different working environment has been done. This shows there is a lack of study in the behavior of three different cold plates at same working environment.

In this work the Optimization is achieved by comparing the thermal characteristics of three types of cold plates at same working environment and proposed the best method that can be adopted in different industrial equipment for safe conditions. The Finite Element Analysis and experimental work has been carried out to validate the results. The conclusion has drawn based on the theoretical data and the results from study.

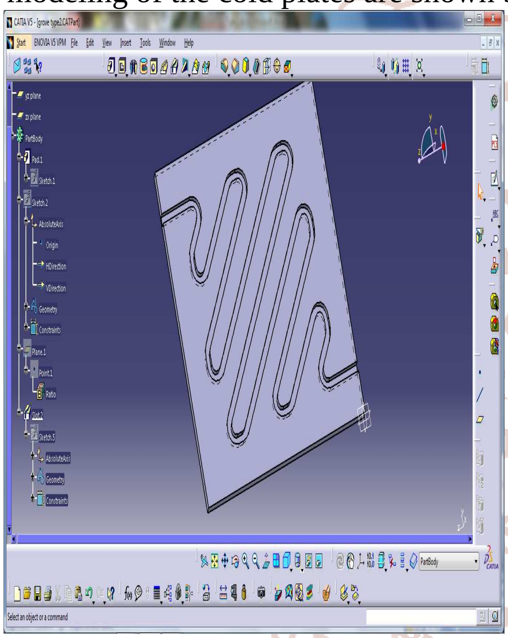
2. MODELING

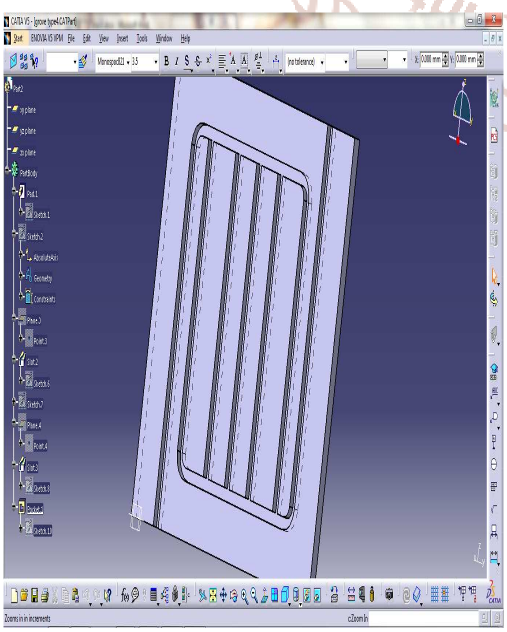
Modeling of four cooling plates are done by using CATIA V5. For all the four cold plates, length, width and thickness are kept constant. Material's considered for all the three plates are same i.e. for plates- copper and for tubes aluminum materials are considered.

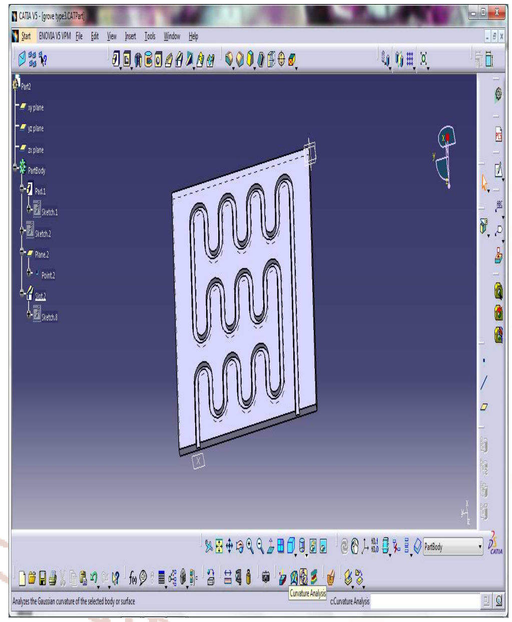
2.1 Model 1 cold plate:

The four cold plates are modeled in CATIA V5R19 version. The size of the plates is 145 mm length and 145 mm width. The groove is made by CNC machining.

The 3D modeling of the cold plates are shown below:-







Density of water = 1000g/m3 Kinematic Viscocity = 8.6 x e-4 m2/s

Sp. Heat = 4.179 KJ/Kg.K

Thermal conductivity = 0.62

Ts = 3530K

T∞ = 2980K

m = Mass flow rate of water = 0.80 kg/sec

T1 = 298 K

Dh = Hydraulic dia (m) = 4A/P

Hypothetical Calculation

Presently, to make hypothetical computations, taking after presumptions are required to make logical counts.

1. The warmth is convected from hot surface as it were.
2. The warmth exchange by conduction of plate is disregarded.
3. The warmth exchanged to chilly water as it were.

The Heat Balance for the plate is given by, Heat convected by Surface = heat gained by the water,

$$hA(T_s - T_\infty) = mC_p(T_2 - T_1)$$

Where,

h = Heat transfer coeffi in W/m^{2}K

T_s = Surface temp. of plate

T_∞ = Final temp. of plate

m = Mass flow rate of water in kg/s

C_p = S_p Heat of water in KJ/KgK

T_1 and T_2 = Inlet and outlet temp. Of water

In the above equation to find out heat transfer coefficient required for convection. The heat transfer coefficient can be obtained by, considering following properties.

3. FINITE ELEMENT ANALYSIS

Transient warmth exchange choose temperatures and other warmth sums that change after some time. The assortment of temperature flow after some time is of energy for a few applications, for instance, with cooling of electronic groups or asmothering examination for warmth treatment. Moreover of interest are the temperature movement realizes warm weights that can achieve disillusionment. In such cases the temperatures from a transient warm examination are used as commitments to a fundamental examination for warm uneasiness evaluations. Transient warm examinations can be performed using the ANSYS solver.

Many warmth trade applications, for instance, warm treatment issues, electronic package arrange, gushes, engine squares, weight vessels, fluid structure affiliation issues, in this way on incorporate transient warmth examinations.

A transient warm investigation can be either straight or nonlinear. Temperature subordinate material properties (warm conductivity, particular warmth or thickness), or temperature subordinate convection coefficients or radiation impacts can bring about nonlinear examinations that require an iterative methodology to accomplish precise arrangements. The warm properties of most materials do change with temperature, so the investigation more often than not is nonlinear.

Typically, a steady-state thermal analysis include several steps.

1. Creating Analysis System
2. Defining Engineering Data
3. Attach/Importing Geometry
4. Defining Part Behavior (domain)
5. Define Connections (Solid Fluid Contact)
6. Applying Mesh Controls/Preview Mesh
7. Establishing Analysis Settings
8. Defining Initial Conditions
9. Applying Loads and Supports
10. Solving by FEA solver
11. Reviewing the Results

Open ANSYS Workbench. From the Toolbox, drag the Transient Thermal format to the Project Schematic.

The ANSYS in transient warm investigation has completed. For this, plate of size 145 x 145 mm is chosen and score of 4 x 4 mm is made as appeared in model. The liquid area is made amongst plate and section. A convection is given to the surface of score. The limit conditions of the surface temperature is 90^0C and the cooling water bay temperature is 25^0C. The yields are characterized by the outlet temperature of cooling water if the plate is cooled by 10^0C. The temperature counters and stream lines are indicated for examination of results. The figures underneath demonstrates the outcomes for the models of cool plates. Final outputs are shown in following figures.

From the cfd analysis temperature distribution was plotted.

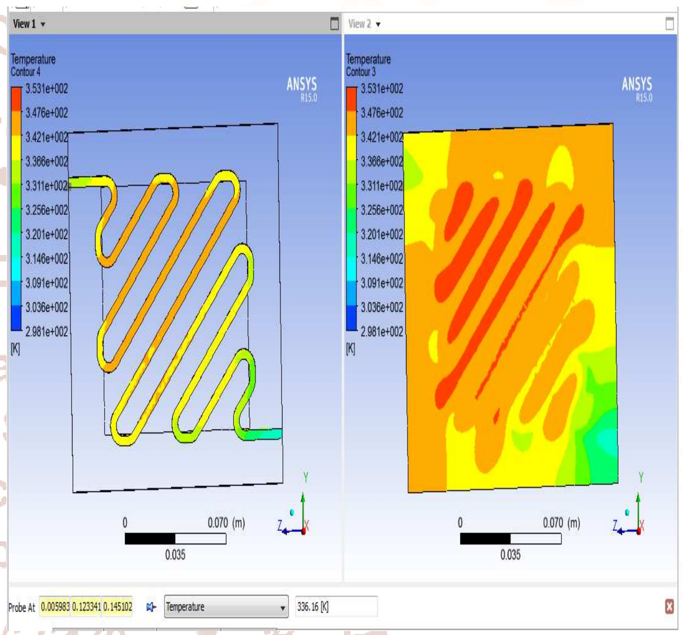


Fig. 5.1: Result of Model 1

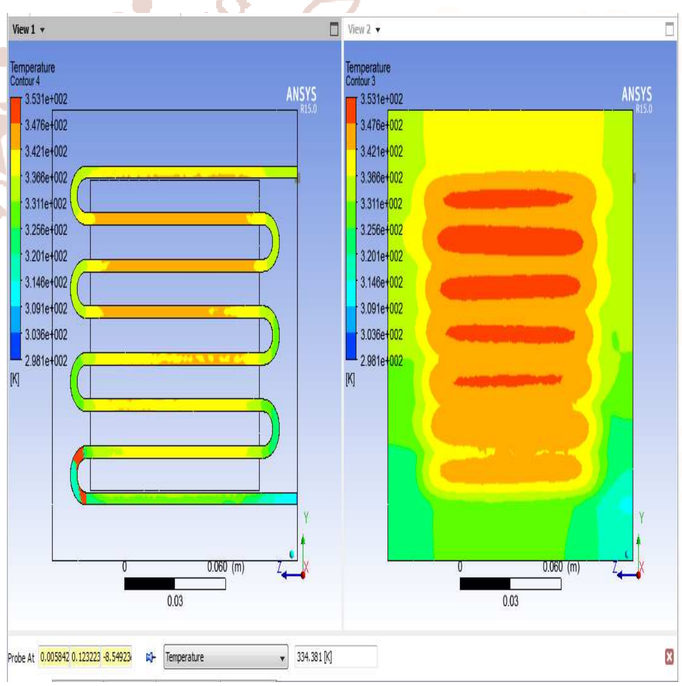


Fig. 5.2: Result of Model 2.

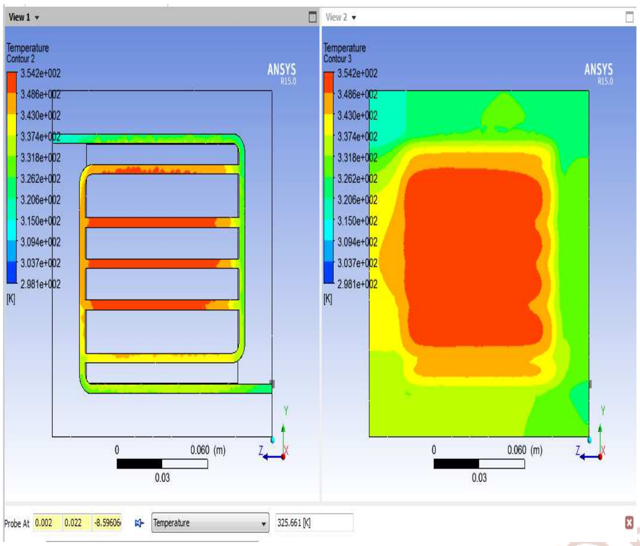


Fig. 5.3: Result of Model 3

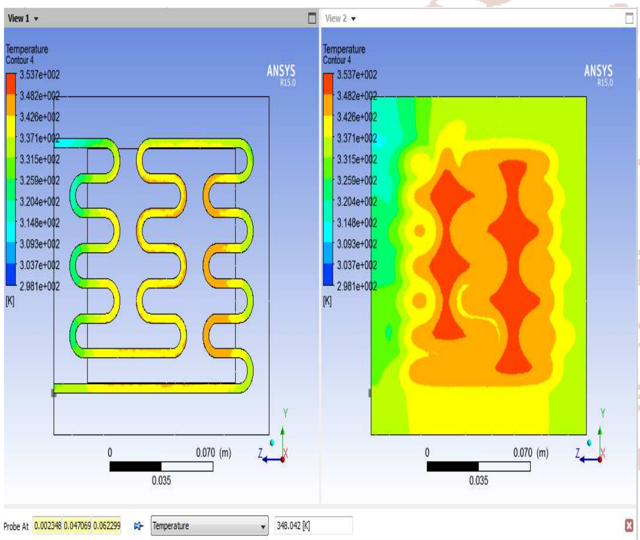


Fig. 5.4: Result of Model 4

The Analysis has been carried out for Model 1, Model 2, Model 3 and Model 4 cold plates. The temperatures obtained of four different cold plates are shown in Table.

Sr. No.	Cold Plates	Analysis Result (K)
1	Model 1	336.16
2	Model 2	334.381
3	Model 3	325.661
4	Model 4	348.042

In all the Four cases the area and thickness of the plates are same. From the analysis Model 1 shows output temperature is 336 K in this case the heat removal rate is less, so this is not withstanding the conditions. In Model 2 cold plate the temperature obtained is 334 K from the results the heat removal rate is less and notwithstanding the criteria. Third model 3 cold plate is attained temperature is 325 K and from the results the heat removal rate is more, this is within the safe limit. Other model 4 cold plate obtained temperature of 348 K which shows less heat removal rate.

Conclusion

The physical characteristics shown in the results are different in each model. From the above results the heat removal rate is more in Model 3 cold plate. When comparing the four cold plates, model 3 cold plate have more contact area to the source, than other three cold plates. By considering these results the behavior showed by the model 3 cold plate is within the safe temperature limit. This is due to carry the more amount of heat according to design of model 3 cold plate and finally this is the best method of cold plate to maintain the industrial equipment in a safe desired conditions. This concludes that, the optimized method i.e. model 3 cold plate can be adopted for heavy electronic equipment and naval applications.

REFERENCES

1. Encyclopedia of thermal packaging Volume 2, Air and Liquid-Cooled Cold Plates, Jan 2015.
2. Wenjun Liu, Hauck Torsten and Josef Drobnik, "Effective Thermal Simulation of Power Electronics in Hybrid and Electric Vehicles", World Electric Vehicle Journal Vol. 5 - ISSN 2032-6653, 2012.
3. Paisarn Naphon, Somchai Wongwises, Songkran Wiriyasart, "On the Thermal Cooling Of Central Processing Unit of the PCs with Vapor Chamber". International Communications in Heat and Mass Transfer 39, 1165–1168, July 2012.
4. Satish G. Kandlikar and Clifford N. Hayner, "Liquid Cooled Cold Plates for Industrial High-Power Electronic Devices - Thermal Design and Manufacturing Considerations". Heat Transfer Engineering, 30: 12, 918 – 930, June 2010.
5. Javier A. Narvaez, Hugh Thornburg, Markus P. Rumpfkeil, Robert J. Wilkens, "Computational Modeling of A Microchannel Cold Plate: Pressure, Velocity and Temperature Profiles", International Journal of Heat and Mass Transfer 78 (2014) 90–98, July 2014.
6. Feng Zhou and Ercan Dede , "A Novel Design of Hybrid Slot Jet and Minichannel Cold Plate for Electronics Cooling", Conference Paper, March 2015, DOI: 10.1109/SEMI-THERM.2015.7100141.

7. Kanchan M. Kelkar, Suhas V, Patankar, “Analysis and Design of Liquid-Cooling Systems Using Flow Network Modeling (FNM)”. International Electronic Packaging Technical Conference and Exhibition July 6-11, July 2003.

8. Hsiao-Kang Ma, Bo-Ren Chen, Jhong-JhihGao, Cheng-Yao Lin, “Development of an OAPCP - Micropump Liquid Cooling System in A Laptop”, International Communications in Heat and Mass Transfer 36, 225–232, Jan 2009.

9. Y. P. Zhang, X. L. Yu, Q. K. Feng, R.T. Zhang, “Thermal Performance Study of Integrated Cold Plate with Power module”, Applied Thermal Engineering 29, 3568–3573, June 2009.

10. Hsiang-Sheng Huang, Ying - CheWeng, Yu - Wei Chang, Sih - Li Chen, Ming -TsunKe, “Thermoelectric Water-Cooling Device Applied to Electronic Equipment”, International Communications in Heat and Mass Transfer 37, 140–146, Sept 2009 .

11. Uma Ravindra Maddipati, P. Rajendran, and P. Laxminarayana, “Thermal Design and Analysis of Cold Plate with Various Proportions of Ethyl Glycol Water Solutions”, International Journal of Advanced Trends in Computer Science and Engineering, Vol.2, No. 6, pages: 22- 25, Nov 2013.

12. Jung - Shun Chen, Jung - Hua Chou, “Cooling Performance of Flat Plate Heat Pipes With Different Liquid Filling Ratios”. International Journal of Heat and Mass Transfer 77, 874–882, June 2014.

13. P. Sivakumar, P. Srihari, Prof. N. HariBabu, “Optimization of Liquid Cold Plates Using Computational Fluid Dynamics”, International Journal of Engineering Trends and Technology (IJETT) – Volume 27 Number 5, September 2015.

14. EVALUATION OF LIQUID COOLING PLATE THROUGH CFD ANALYSIS Dupati Ramesh Babu1* and V Krishna Reddy2 IJERST ISSN 2319-5991 Vol. 3, No. 4, November 2014