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A review on Transient Heat Flow Analysis of Cold Plate Used in Electronic Power Cooling Systems

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Abstract: **Water cooling is the technology used for industries to remove heat from devices including mechanical, electronic, and applied domain with the help of cold plates in condenser type devices. Today the application of water cooling is not only for mechanical but also it can be applied to electronic applications. Normally electronic applications having VLSI systems, Due to transmission of electrical properties sometimes the temperature of the electrical circuit plate goes more than designed level. The electronic applications may fail in operation because of this excess temperature. Normally the designed temperature for electronic applications ranges to 90^{0}C. So, provision is needed to control temperature for safety regulation of electronic work.**

The paper presents literature on transient heat flow analysis through cold plate. Several researches from researchers have been discussed here. The concept of transient heat flow is discussed with example of cold plate made in CATIA V5R19 and analyze in ANSYS software.

Keywords: **ANSYS, CATIA, Cold Plates, Electronic Applications, Temperature, Transient Heat Transfer, VLSI, Water Cooling, etc.**

I. INTRODUCTION

The high thermal interactions are achieved during operations of heavy electronic circuits. The average safe temperature limit for the electronic circuit has been found to be 90^{0}C.This rise in temperature will have an antagonistic impact on the parts and sometimes fails to operate with speed, results in diminishing of the part's life time. So it is need of industry to kept temperature below 90^{0}C observed in circuits. An improved method of water cooling is better technology to solve such problems. Since there is convective heat exchange takes place around system.

The heat exchange by convective type will takes place by cooling plate. The cooling plate is simply a plate made up of high convection property material like aluminum and copper. It has grooves at different orientations. This plate is mounted at the surface below electronic circuit. The coolant usually water or mixture of water and refrigerant flows from the grooves at specific flow rate. The cooling is processed by exchanging heat from surface of circuit to the coolant, so that there is increase in the temperature of coolant.

The cooling plates have certain sorts relies on upon size, shape, introduction, and application. Taking after are the three principle orders of the cooling plates:

1) Formed Tube Type (FTT)
2) Deep Drilled Type (DDT)
3) Machined channel Type (MCT)

FTT ensure minimum warm resistance between the electronic gadget and fluid plate by streaming the coolant tube in direct contact with the contraption base plate. In this arrangement, copper plate is generally used, notwithstanding the way that aluminum is as a less than dependable rule used in low power applications.

A DDT trade more warmth flux and power dispersing augmentations, the contact resistance of the plate and the tube divider ended up being unsuitably high. In this plate, the drills are entered in the plane of ensuing plate.

The MCCP give better outcomes contrasted and different sorts. The plate is made by machining the depression on the surface of the plate and cover for the entry to stream coolant. It enhances warm execution of the plate.

The exchange of heat between circuit surface and cooling plate takes place transiently and totally depends on temperatures of both surfaces and cooling water properties.

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The present study based on review of literatures to find the optimum results. The various types of cold plates are shown in figure 1-3.

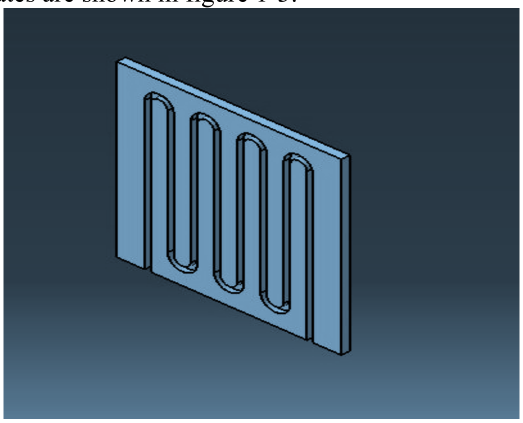

Figure 1 Formed Tube Cold Plate

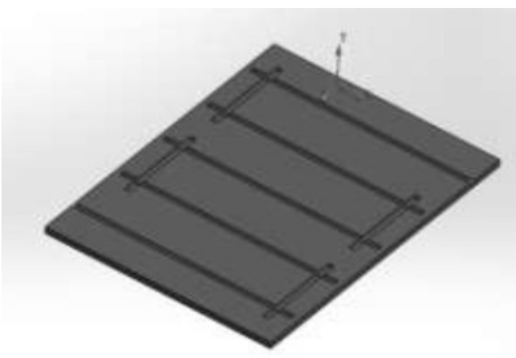

Figure 2 Dip Drilled Cold Plate

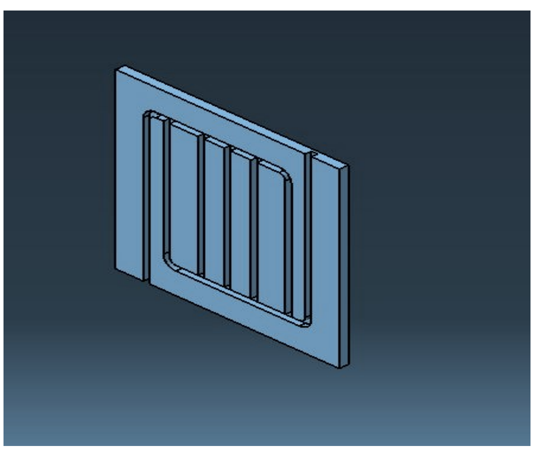

Figure 3 Machined Channel Cold Plate

II. LITERATURE REVIEW

The physical attributes appeared in the outcomes are diverse in every model. From the study the warmth evacuation rate is more in profound DDT plate. At the point when contrasting the weights of three cool plates, DDT plate have less in weight, than other two cool plates. By considering these outcomes the conduct appeared by the DDT plate is inside the safe temperature restrain. This is because of convey the more sum of warmth as per outline of DDT plate lastly this is the best strategy for cool plate to keep up the modern gear in a safe wanted conditions. This reasons, the improved strategy i.e. DDT can be embraced for overwhelming electronic gear and maritime applications. [1]

This examination extend has had two rule foci. The first is the improvement of a reproduction methodology which empowers the liquid stream and warmth move in long, intermittent chilly plates to be illuminated by concentrating on a solitary, agent module of the exhibit. This new technique decreases a profoundly complex conjugate liquid stream and warmth exchange issue to one which is restricted to warmth conduction in the strong dividers of the icy plate. The second concentration, which is a use of the new reproduction system, is to recognize warm exchange improvement procedures which additionally empower proficient creation free from the need of utilizing brazing-sort producing techniques. Specifically, the approach embraced here depended on an assembling technique, contact blend welding, which yields an exceedingly stable structure fit for withstanding high weights.

To instate the outline procedure, it was initially chosen to utilize fundamental balances whose impression concurred with that of the warmth stack locales. It was contemplated that the fundamental way of the blades would be very powerful in exchanging heat as well as give critical auxiliary support. Computational tests were then performed to analyze the subsequent liquid stream design in the region of the balances. That evaluation uncovered the need to find a way to coordinate the stream to accomplish fiery contact between the coolant and the surfaces of the balances. To this end, stream coordinating confuses were utilized. [2]

By and large, plan streamlining has been successful in acquiring an ideal punctured plate outline, inside an auspicious way and with minimized client input. Utilizing an inbuilt computerized advancement instrument inside the CFD programming, the client input required in making geometric and fitting adjustments was enormously decreased. It is conceivable that similar conclusions could have been discovered utilizing a more manual approach, however the time and client input required to do this would have been altogether more prominent in correlation. [3]

ANSYS was utilized to supplement scientific techniques in the outline of another Guarded Hot Plate mechanical assembly to gauge the warm conductivity of warm protection. The limited component reenactments empowered originators to figure out if radiator and coolant tube formats would produce a uniform temperature profile on surfaces confronting the example. Examinations additionally guaranteed architects that one-dimensional warmth exchange would be available in the meter segment of the example. The utilization of ANSYS has given more noteworthy understanding into the material science of the mechanical assembly and will empower NIST to make estimations with more prominent exactness. [4]

The copper tube frosty plates, having bigger trademark measurements, depend on transitional or turbulent streams to accomplish warm exchange execution while the machined icy plates with littler trademark measurements depend on vast wetted territories to accomplish execution. Since the two sorts of icy plates looked at in this review have altogether different weight drop attributes, executions of the two sorts would fundamentally require dissimilar stream rates (high stream rates for the shaped tubes, and much lower stream rates for the little machined channels). The warm resistance ascertained incorporates the temperature ascent of the liquid inside the frosty plate certainly. [5]

In this venture outline enhancement of the icy plates utilized as a part of protection power hardware was done. Conjugate Heat Transfer Analysis of the IGBT cooling plate is completed utilizing the CFD programming to archive the temperature circulation, speed of stream and the weight drop. Plan advancement of the frosty plate was finished to accomplish the temperature of under 85 degrees, which is an outline requirement.

Enhancement is finished by changing the profile of stream channels, keeping bay and outlet distances across steady. Three such emphases have been performed and the outcomes are thought about. From the outcomes that the most extreme temperature of 370 K (97 0C),368 (95 0C) and 354 (81 0C) is watched for unique, adjusted model-1 and altered model- 2 individually. Henceforth it is presumed that the changed model-2 is the best outline of frosty plate to keep up the temperature inside the outline limits. [6]

III. METHODOLOGY

The two chilly plates are demonstrated in CATIA V5R19 form. The extent of the plates is 145 mm length and 145 mm width. The groove is made by CNC machining. The one plate having groove along vertical heading while other plate having corner to corner. The main plate is displayed as model 1 and other plate is demonstrated as model 2 as appeared in figure 4-5.

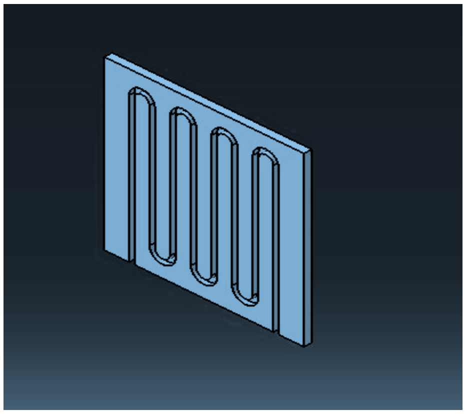

Figure 4 Model 1 (Linear Groove)

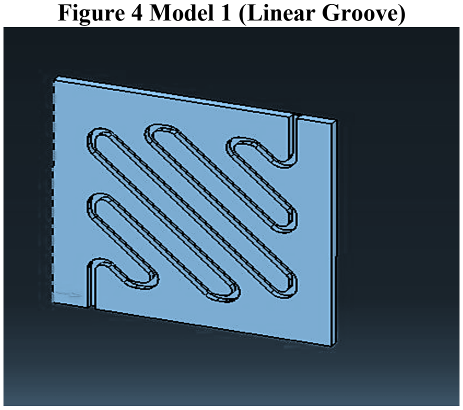

Figure 5 Model 2 (corner Groove)

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,

$$hA(T_s - T_\infty) = mC_p(T_{wo} - T_{wi})$$

Where,

h = Heat Transfer Coeff. in W/m²K → h = Heat Transfer Coeff. in W/m^2K

T_s = *Surface temp. of plate.*

T_∞ = *final Temp. of plate.*

m = *Mass flow rate of water = 0.05 Kg/sec.*

C_p = *Sp. Heat of Water in KJ/KgK*

T_{wi} *and* T_{wo} = *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:

Density of water = 1000 Kg/m^3

Kinematic Viscosity = $8.6\times e^{-4}$ m^2/s

Sp. Heat = 4.179 KJ/Kg.K

Thermal Conductivity = 0.62

$T_s = 353^0K$

$T_\infty = 298^0K$

m = Mass flow rate of water = 50 g/sec.

$T_{wi} = 298^0K$

D_h = *Hydraulic dia. (m) = 4A/P*

Where, A is Area of groove and P= Perimeter.

Pr = 7.02,

$Re = {\rho VD}/{\mu}$

$Nu = \frac{hl}{K}$

From above equations, the heat transfer coefficient is,

$h = 155\ W/m^2K$

Now, applying heat balance to the system to find out outlet temp of water.

IV. 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 a smothering 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 or Samcef 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 or the Transient Thermal (Samcef) format to the Project Schematic.

There are a few material in the Engineering Data Sources that we can utilize straightforwardly. By tapping the Engineering Data Sources, then Thermal Material, then tapping the in addition to close Copper. Import the geometry in IGES organize. There are no particular contemplations for enduring state warm investigation itself. Be that as it may if the temperatures from this investigation are to be utilized as a part of a consequent basic examination the work must be indistinuishable. Hence for this situation you might need to ensure the work is sufficiently fine for basic investigation. The ANSYS in transient warm investigation has completed. For this, a plate of size 145*145 mm is chosen and score of 4*4 mm is made as appeared in model 1 and model 2 from figure 4-5. The liquid area is made amongst plate and section. A convection is given to the surface of score. The limit conditions are the surface temp. is 80^{0}C and the cooling water bay temp. is 25^{0}C. the yields are characterized by the outlet temp. of cooling water if the plate is cooled by 10^{0}C. The temp. Counters and stream lines are indicated for examination of results. The figures underneath demonstrates the outcomes for the two models of cool plates.

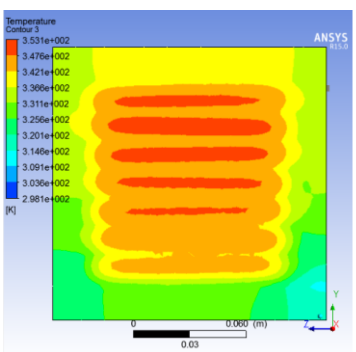

Figure 6 Result of Model 1

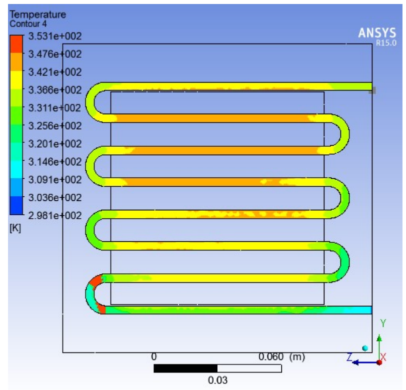

Figure 7 Result of Model 1

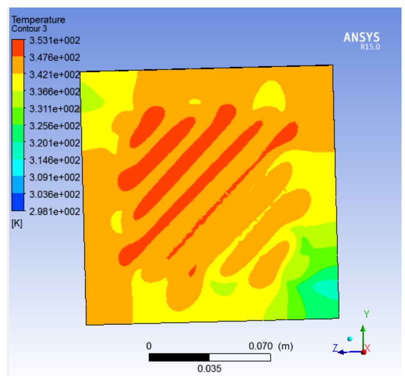

Figure 8 Result of Model 2

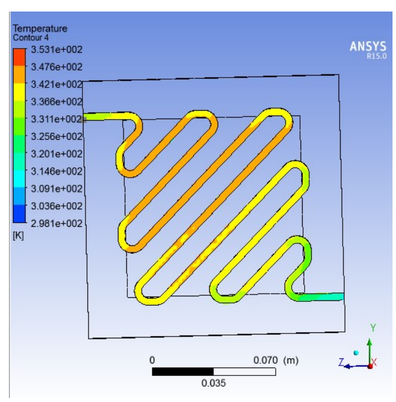

Figure 9 Result of Model 2

Table 1 Comparison of Outlet Temp.(K) of Cooling Water by Theoretical and Finite Element Analysis

Sr. No.	Model Type	Theoretical	Finite Element Analysis	% Error
1	Model 1	342	336	1.75
2	Model 2	348	342	1.72

V. CONCLUSION

The physical attributes appeared in the outcomes are distinctive in every model. From the above outcomes the warmth evacuation rate is more in Model 2. At the point when looking at the weights of these chilly plates, Model 1 cool plate has less in weight, than Model 2 icy plate. By considering these outcomes the conduct appeared by the Model 2 frosty plate is inside the protected temperature constrain. This is because of convey the more measure of warmth as indicated by outline of Model 2 frosty plate lastly this is the best technique for chilly plate to keep up the modern hardware in a safe coveted conditions. This infers, the enhanced strategy i.e. Display 2 icy plate can be embraced for mechanical purposes.

REFERENCES

[1] Ephraim M. Sparrow, "The Design of Cold Plates for the Thermal Management of Electronic Equipment", Heat Transfer Engineering, August 2006, pp. 3-6.

[2] Matthew V. Horgan, "Application of Design Optimization to ESP Particle Capture", Ninth International Conference on CFD in the Minerals and Process Industries, 10-12 December 2012, pp. 1-6.

[3] William M. Healy, "Using Finite Element Analysis to Design a New Guarded Hot Plate Apparatus for Measuring the Thermal Conductivity of Insulating Materials", National Institute of Standards and Technology, October 2001, pp. 1-9.

[4] Michael Ellsworth, "Technical Brief: Design Considerations for High Performance Processor Liquid Cooled Cold Plates", Liquid Cooling, Number 4, Technical Brief, Volume 17, pp. 1-10.

[5] Dupati Ramesh Babu, V Krishna Reddy, "Evaluation of Liquid Cooling Plate through CFD Analysis", International Jourbnal of Engineering Research and Science and Technology, Vol.3, no. 4, Nov 2014, pp. 178-182.

[6] Satish G. Kandlikar and Clifford N. Hayner, "Liquid Cooled Cold Plates For Industrial High-Power Electronic Devices—Thermal Design and Manufacturing Considerations, Journal of Heat Transfer Engineering, Vol. 30, Issue 12, 2009, Pp. 918–930.

[7] Priyanka G, M. R. Nagraj, "CFD Analysis of Shell and Tube Heat Exchanger With and Without Fins for Waste Heat Recovery Applications, International Journal of Science and Research, Volume 3 Issue 7, July 2014, pp. 1437-1441.

[8] Kanchan M. Kelkar, "Analysis and Design of Liquid-Cooling Systems Using Flow Network Modeling, Proceedings of IPACK03, International Electronic Packaging Technical Conference and Exhibition, July 6-11, 2003, Pp. 1-6.