International Journal of Engineering Research and Science & Technology

ISSN : 2319-5991
Vol. 3, No. 4
November 2014

www.ijerst.com

Email: editorijerst@gmail.com or editor@ijerst.com

International Journal of Engineering Research and Science & Technology

ISSN 2319-5991 www.ijerst.com
Vol. 3, No. 4, November 2014

Research Paper

EVALUATION OF LIQUID COOLING PLATE THROUGH CFD ANALYSIS

Dupati Ramesh Babu[1]* and V Krishna Reddy[2]

*Corresponding Author: **Dupati Ramesh Babu** ✉ assis.s08@gmail.com

This project deals with the design optimization of the cold plates used in defence power electronics. The objective of the work carried is to reduce thermal resistance, increase heat transfer rates, and use light-weight material.CFD analysis is performed to characterize thermal performance based on steady-state loading conditions. Conjugate Heat Transfer Analysis of the IGBT cooling plate is carried using the CFD software to document the temperature distribution, velocity of flow and the pressure drop. Best Design of the cooling plate was evaluated based on the better temperature distribution and more heat transfer rate of the cooling plate. The cooling plate designed in this project is used to mount 8 IGBTs. The IGBT cooling plate is used in defence electronics. The cooling plate is designed in solid works software and the flow analysis is carried out using the solid works flow simulation software. Design optimization of the cold plate was done to achieve the temperature of less than 85 degrees, which is a design constraint. Optimization is done by changing the profile of flow channels, keeping inlet and outlet diameters constant. Three such iterations have been performed and the results are compared and tabulated.

Keywords: Cold plats, Thermal resistance, Heat transfer rates, CFD Analysis

INTRODUCTION

Electronic devices are at the heart of almost all major industrial and military equipment. Some of these are power drives, insulated-gate bipolar transistor (IGBT) controllers, radio-frequency (RF) generators, magnetic resonance imaging (MRI) machines, traction devices for locomotives, battery chargers, UPS (uninterrupted power systems), DC-AC converters, AC-DC inverters, and army tanks (using transmission fluid already at a high temperature). The high-power, high-heat-flux demands on the cooling system cannot be met with air cooling, and advanced liquid cooling solutions are necessary.

There has been a dramatic shift in cooling high-power devices in the industry during the past decade. Air cooling has sufficed for many lower power electronic devices. Although it is quite difficult to make a distinction based on total power dissipation, it seems that beyond a range of about

[1] M.Tech Student, Krishnachaitanya Institute of Technology & Sciences, Markapur – 523316, Prakasam District, Andhra Pradesh, India.
[2] Professor, Krishnachaitanya Institute of Technology & Sciences, Markapur – 523316, Prakasam District, Andhra Pradesh, India.

1500Wdissipation, there are many physical and design constraints that may dictate a shift toward liquid as the preferred medium.

PROBLEM DEFINITION

This project deals with the evaluation of the best design with the different inlet and outlet diameters of the cooling plates by performing CFD analysis. The cooling plate is used in defence power electronics. CFD analysis is performed to characterize thermal performance based on steady-state loading conditions. Conjugate Heat Transfer Analysis of the IGBT cooling plate is carried using the CFD software to document the temperature distribution and the pressure distribution. Design evaluation of the cooling plate was done for better temperature distribution.

The cold plates is designed in solid works software and the flow analysis is carried out using the solid works flow simulation software. The cooling plate is made up of two copper plates sandwiched together by soldering. The inside of cooling plates contains flow channels. The coolant considered in this analysis is de-ionized water. CFD analysis was carried out using Solid works flow simulation. The temperature distribution and pressure plots are observed and documented. Design evaluation of the cooling plate was carried out based on the better heat transfer rate and less temperature distribution.

METHODOLOGY

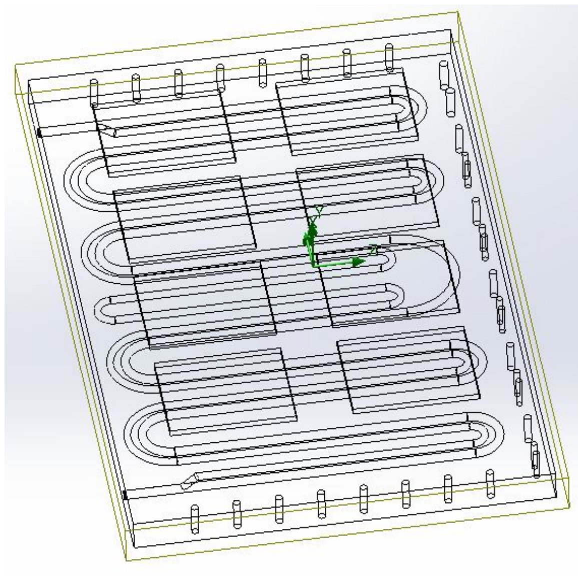
The objective is to evaluate a cooling plate which has a comparable ability to cool the integrated power electronics module.

- 3D model of the cooling plates with different flow channel profiles by keeping inlet and outlet diameters constant was developed from the 2D drawings using Solid works software.
- The 3D model is imported into Solid works flow environment to perform the CFD analysis.
- Temperature, Velocity and Pressure distribution are observed and documented.
- Results, discussions, comparison and conclusions of the results of different cooling plates shall be made.

3D MODELLING

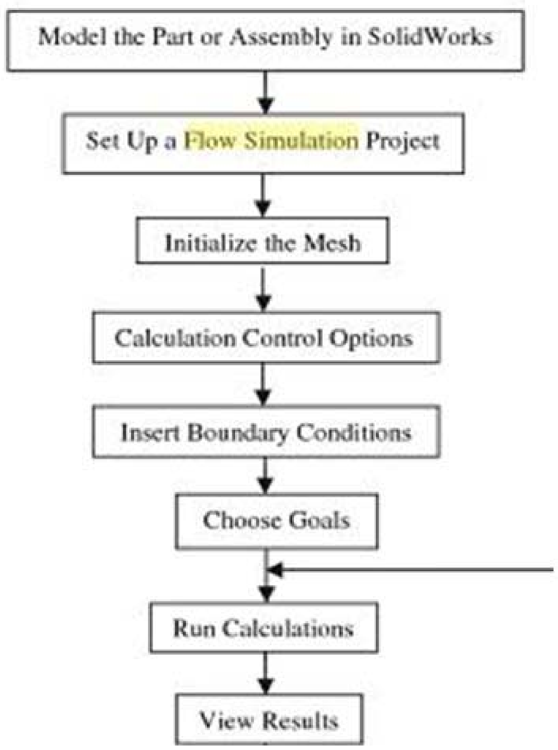
3D model of the cooling plates with different flow channel profiles by keeping inlet and outlet diameters constant was developed from the 2D drawings using Solid works software. The 3D model is imported into Solid works flow environment to perform the CFD analysis

Figure 1: 3D Model of the Formed Tube Cold Plate (FTCP)



SOLIDWORKS FLOW SIMULATION

Figure 2: Flow Simulation Flow Chart



BOUNDARY CONDITIONS

For liquid cold plate , inlet lids and out lids are created to make a fluid model, mass flow rate at inlet lid and Static Pressure at outlet lid are applied as boundary conditions.

Inlet mass flow: 1.89 Kg/s

Static Pressure: 101325 Pa

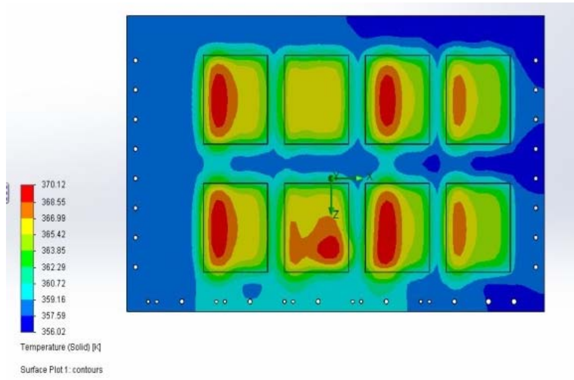
RESULTS

Temperature on the cold plate(Iteration 1):Temperature for cooling plate(Iteration 1):

From the cfd analysis temperature distribution was plotted. The maximum temperature observed on the cooling plate is 370 K as shown in the below Figure 3.

From above results, temperature is plotted, it is observed that temperature on the cold plate is

Figure 3: Temperature for Cooling Plate (iteration 1)



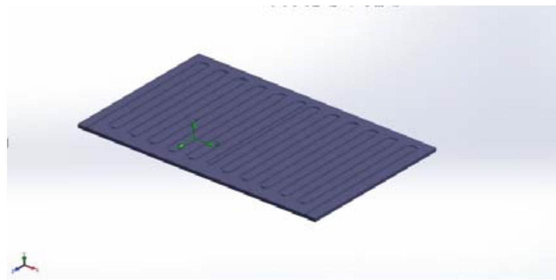
good but number of flow channels are not sufficient to cool the liquid cold plate. So it is required to increase the number of flow channels in order to reduce the temperature distribution.

MODIFIED MODEL -1 FOR LIQUID COLD PLATE

For Iteration 2

3D model for modified cold plate: For iteration2 number of channels has been increased for temperature distribution. Plate length, thickness and width are kept constant.

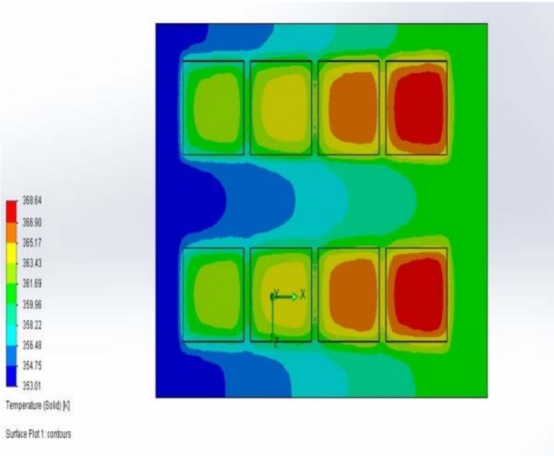
Figure 4: Isometric View for Modified Top Plate



RESULTS FOR ITERATION 2

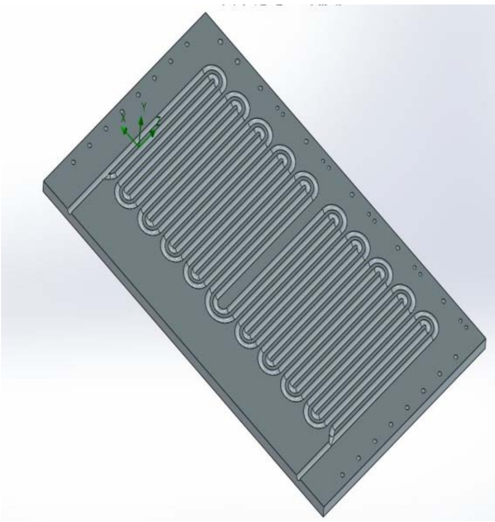
Temperature for cooling plate (Iteration 2): From cfd analysis temperature distribution was plotted. The maximum temperature observed on the cooling plate is 368 K as shown in the below figure.

Figure 5: Temperature on the Cooling Plate (iteration 2)



From this it can be observed that max temperature for fluid flow is 368 K. Further modifications are carried out on the cooling plate to reduce the temperature distribution.

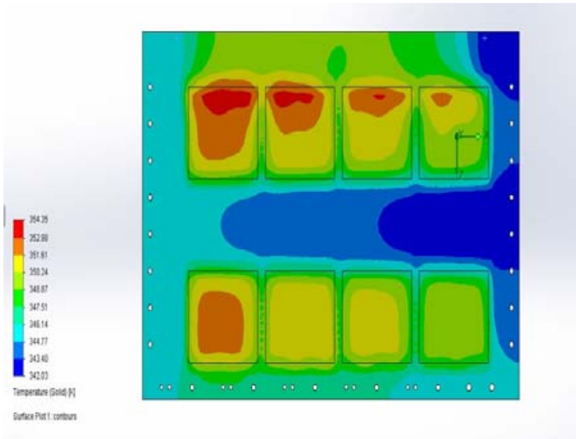
Figure 6: 3d Modelling For Modified -2 Cold Plate



RESULTS FOR MODIFIED-2 COLD PLATE

Temperature distribution on the cooling plate (Iteration 3): From cfd analysis Temperature was plotted. The maximum temperature observed on the cooling plate is 354 K as shown in the figure.

Figure 7: shows Temperature on the Cooling Plate (iteration 3)



It is observed that the max temperature of the fluid flow is 354 K. From the above results it can be said that temperature distribution is in the design limits and can be used to cool the electronic equipment.

RESULTS AND DISCUSSION

Liquid cold plate has been designed and been analyzed for temperature distribution. Initially CFD Analysis is done for liquid cold plate. From the original model results have been plotted i.e. Temperature distribution, Pressure and Velocity. From the results it is observed that maximum temperature on the cold plate is 370 K .The temperature is out of the design limits, for decreasing the temperature design changes are done on the model by increasing number of flow channels. In the modified model the number of channels are increased and also CFD Analysis was done on the modified model and temperature, pressure and velocity are plotted. From the results it is observed that maximum temperature on the cold plate is 368 K. Further modifications are carried out on the cooling plate to reduce the temperature distribution. In modified-2 model number of flow channels are further increased keeping length, width and thickness constant. From the CFD results it is observed that maximum temperature on the cold plate is 354 K. In modified-2 model Temperature is within the design limits. The comparison of the results for all the cases were tabulated in Table 1.

Table 1: Comparison of Case Results

S.No.	Results	Original Model	Modified Model-1	Modified Model-2
1	Temperature	370	368	354
2	Pressure	9286508	3.88E+07	1.33E+07
3	velocity	77.529	94	77.503

CONCLUSION

In this project design optimization of the cold plates used in defence power electronics was done. Conjugate Heat Transfer Analysis of the IGBT cooling plate is carried out using the CFD software to document the temperature distribution, velocity of flow and the pressure drop. Design optimization of the cold plate was done to achieve the temperature of less than 85 degrees, which is a design constraint. Optimization is done by changing the profile of flow channels, keeping inlet and outlet diameters constant. Three such iterations have been performed and the results are compared. From the results that the maximum temperature of 370 K (97 ^{0}C),368 (95 ^{0}C) and 354 (81 ^{0}C) is observed for original, modified model-1 and modified model-2 respectively. Hence it is concluded that the modified model-2 is the best design of cold plate to maintain the temperature within the design limits.

REFERENCES

1. Ellsworth Jr. M J, Campbell L A, Simons R E, Iyengar M K, Schmidt R R and Chu R C (2008), "The Evolution of Water Cooling for IBM Large Server Systems: Back to the Future", *Proceedings of the 2008 ITherm Conference*, Orlando, FL, USA, May 28-31.
2. Ellsworth Jr. M J, Goth G F, Zoodsma R J, Arvelo A, Campbell L A, Anderl W J (2011), "An Overview of the IBM Power 775 Supercomputer Water Cooling System", *Proceedings of the ASME 2011 Pacific Rim Technical Conference & Exposition on Packaging and Integration of Electronic and Photonic Systems (InterPACK 2011)*, Portland, Oregon, USA, July 6-8.
3. Kaneko K, Kuwabara K, Kikuchi S and Kano T (1991), "Hardware Technology for Fujitsu VP2000 Series", *Fujitsu Scientific & Technology Journal*, Vol. 37, No. 2, pp. 158-168.
4. Kaneko K, Seyama K and Suzuki M (1990), "LSI Packaging and Cooling Technologies for Fujitsu VP2000 Series", *Fujitsu Scientific & Technology Journal,* Vol. 41, No. 1, pp. 12-19.
5. Kobayashi F, Watanabe Y, Yamamoto M, Anzai A, Takahashi A, Daikoku T and Fujita T (1991), "Hardware Technology for Hitachi M-880 Processor Group", *Proceedings of the 41st Electronic Components and Technology Conference*, pp. 693-703.
6. Murano H and Watari T (1992), "Packaging technology for the NEC SX-3 Supercomputers", *IEEE Transactions on Components, Hybrids, and Manufacturing Technology*, Vol. 15, No. 4, pp. 411-417.

7. Sahan R A, Rahima M K, Xia A and Pang Y F (2011), "Advanced Liquid Cooling Technology Evaluation for High Powered CPUs and GPUs", *Proceedings of InterPACK 2011*, Portland, Oregon, USA, July 6-8.

8. Simons R E (1995), "The Evolution of IBM High Performance Cooling Technology", *Proceedings of the Eleventh Annual IEEE Semiconductor Thermal Measurement and Management Symposium*, pp. 102-112.

9. Watari T and Murano H (1985), "Packaging Technology for the NEC SX Super-computer", *IEEE Transactions on Components, Hybrids, and Manufacturing Technology,* Vol. 8, No. 4, pp. 462-467

10. Wei J (2011), "Hybrid Cooling Technology for Large-Scale Computing Systems – From Back to the Future", *Proceedings of InterPACK 2011*, Portland, Oregon, USA, July 6-8.

International Journal of Engineering Research and Science & Technology
Hyderabad, INDIA. Ph: +91-09441351700, 09059645577
E-mail: editorijlerst@gmail.com or editor@ijerst.com
Website: www.ijerst.com

ISSN 2319-5991