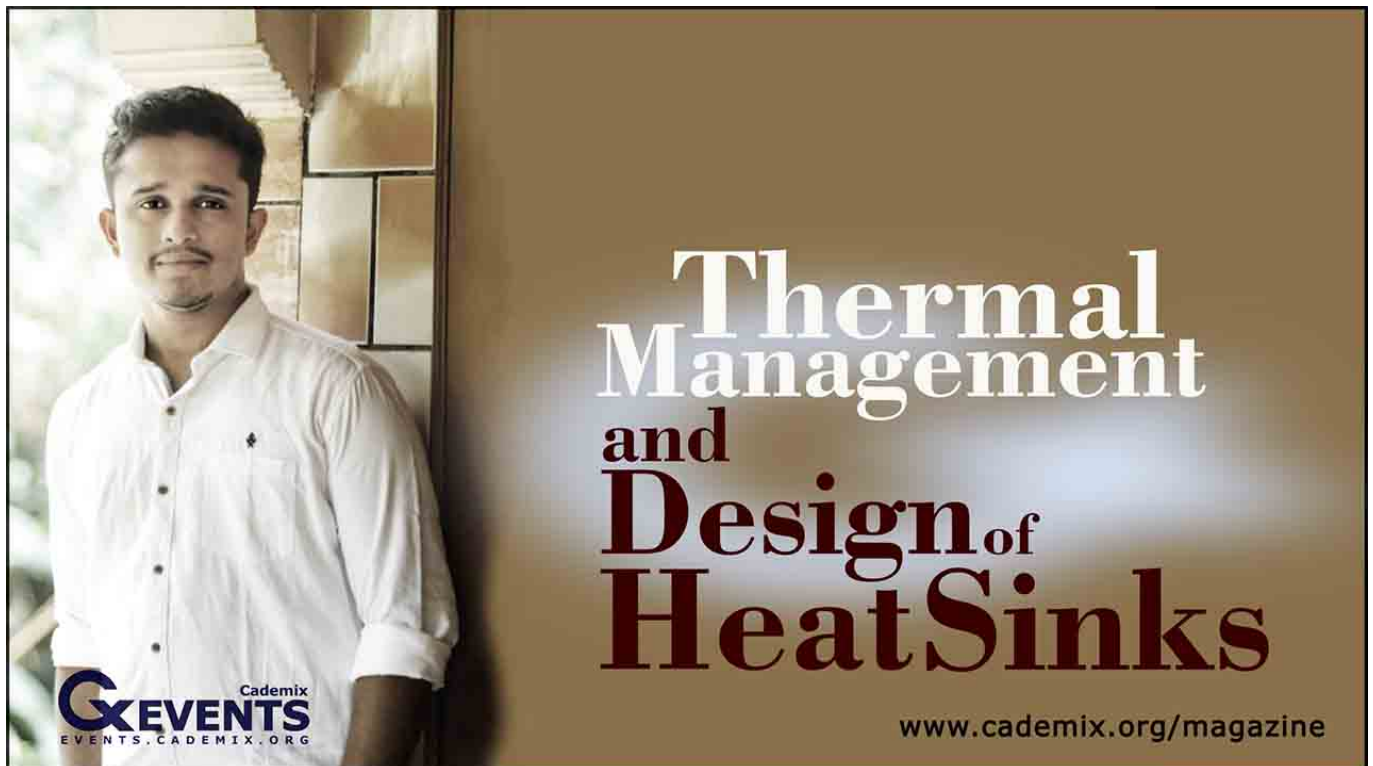


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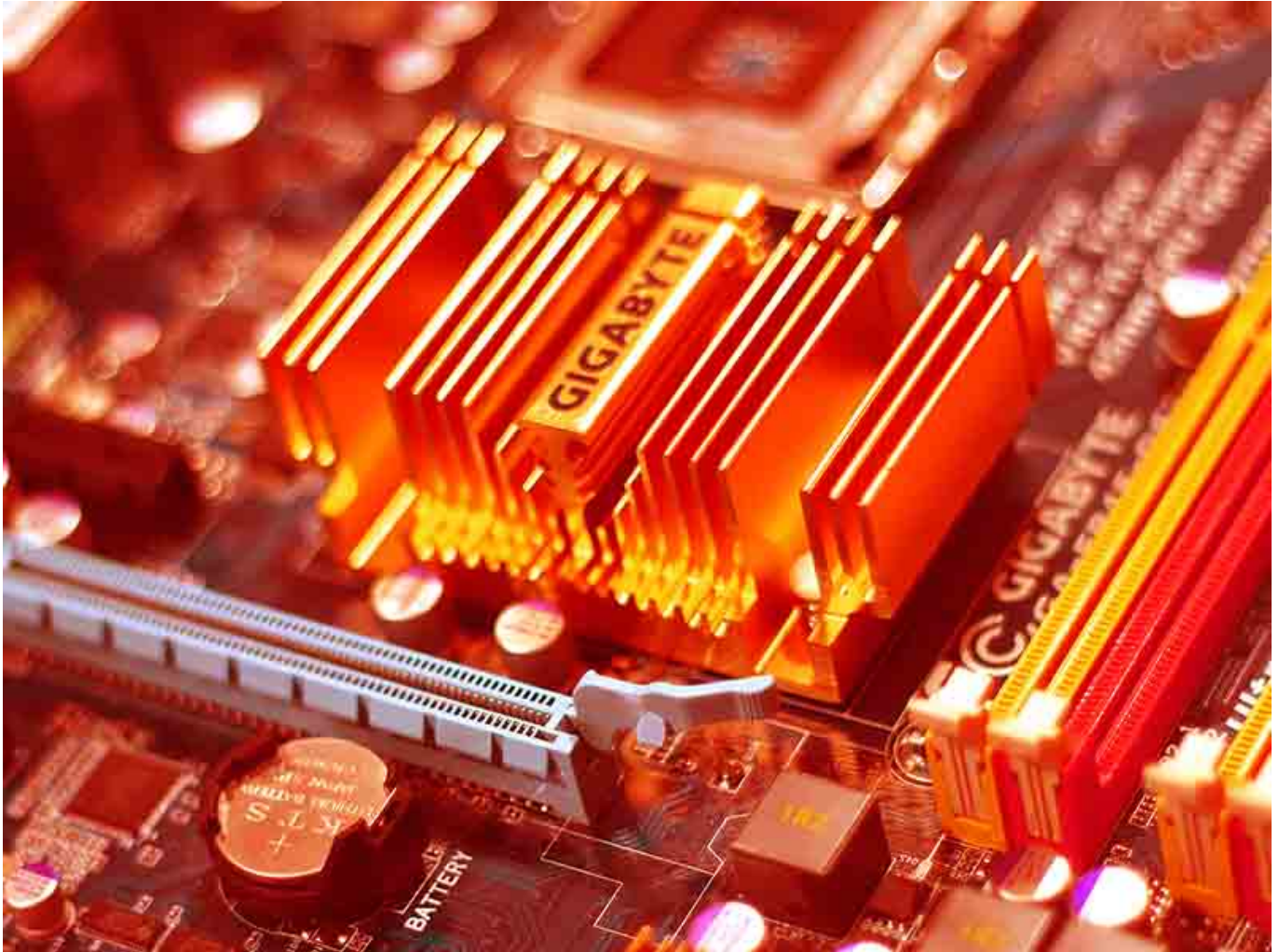
## Thermal Management and Design of Heat Sinks

By: Jewel Antony, Associate Researcher with Cademix & Mechanical Engineer

“Studies show that investments to spur renewable energy and boost energy efficiency generate far more jobs than oil and coal.” ~ *Jeff Goodell*



Thermal Management is a multidisciplinary area related to energy efficiency and design optimization. To improve reliability and prevent premature failure, all electronic devices and circuits which generate excess heat, require thermal management. In a closed system, where there are no other energy interactions, the amount of heat output is equal to the power input. There are several cooling techniques including different heat sink styles, thermo-electric coolers, forced air systems and fans, heat pipes, and many other techniques. In cases of extreme low ambient temperatures, heating of the electronic components may be extremely necessary to maintain satisfactory operation. In this article we study a few aspects of thermal management and design of heat sinks.



View of a Computer Motherboard and the heat sink by Gigabyte.

## Heat Sinks

Heat sinks (also commonly written heatsinks) are passive heat transmission and exchanger devices that transfers the heat generated by an electronic or mechanical system. They transmit the extra heat to the surroundings medium, usually the ambient air or liquid coolant. As a results, they dissipate away the heat from the system, and thus permitting temperature management of the device.

Heat sinks are important parts of electronic components to maintain them under the maximum allowed operational temperature and power. There are several methods to enhance the efficiency of heat sink, such as forced air cooling of heatsink Varieties of heatsink designs are proposed by specialized industries to cool different kinds of electronic components. However, in most cases we just need an appropriate heatsink to each specific case and particularly under transient heat generation that can be caused by many electronic or power

electronic devices. The design optimization process usually includes a computer simulation based on Finite Element Analysis.

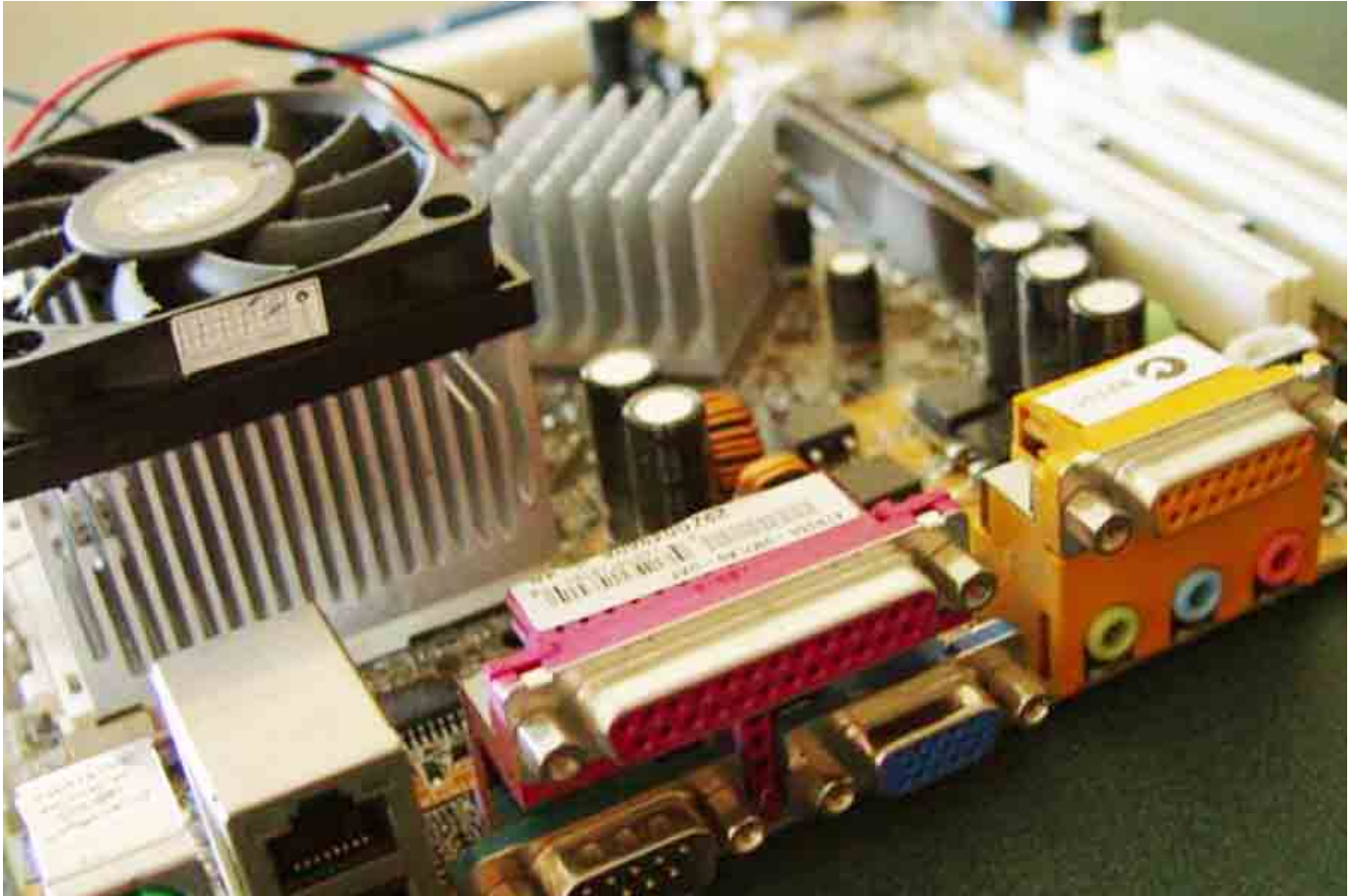
## Computer Simulation of Heat sinks

A typical simulation of heat sinks includes an analysis focused on thermal performance of an industrial heat sink. The simulations are based on a single thermal analysis and finite element simulation. More accurate analysis are usually based on a transient analysis where the time dependency is included in the analysis. For many optimization problem though, it is enough to perform a steady state thermal analysis.

In a finite element analysis, it is not required to include all the geometrical details of the surrounding, rather they will be included in the analysis using their equivalent simplified geometries or rather the structural repetitions may be simplified as periodic boundary conditions in the simulation. Even the design may be simplified as a two dimensional model in certain analyses. It is however very important to consider the accurate material models of the major heat sink in the analysis. A detailed temperature dependent material properties may be required.

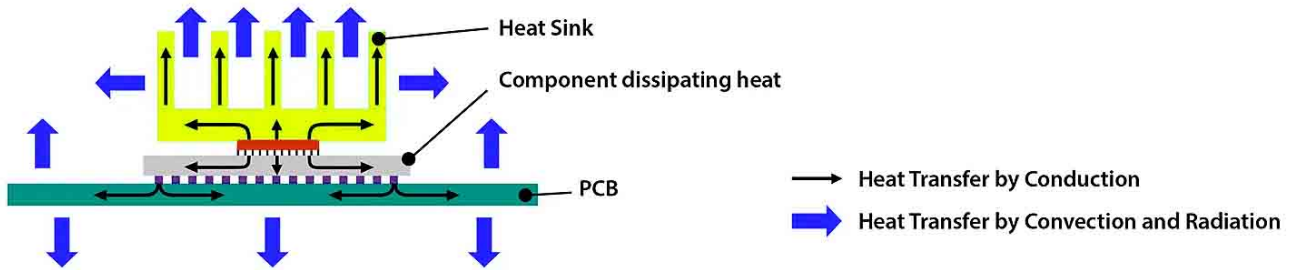
In the more sophisticated analysis, the researcher may even include the Computational Fluid Dynamics (CFD) simulations to determine the cooling performance of the actual heat sink under an active cooling like a air fan.





The heat transfer from the heat sink occurs by three mechanisms. First convection of the surrounding air, second, conduction through the air, and third the radiation. All of these depend on the geometry, material selection and boundary conditions. Heat transfer by radiation is a function of both the heat sink temperature, and the ambient temperature.

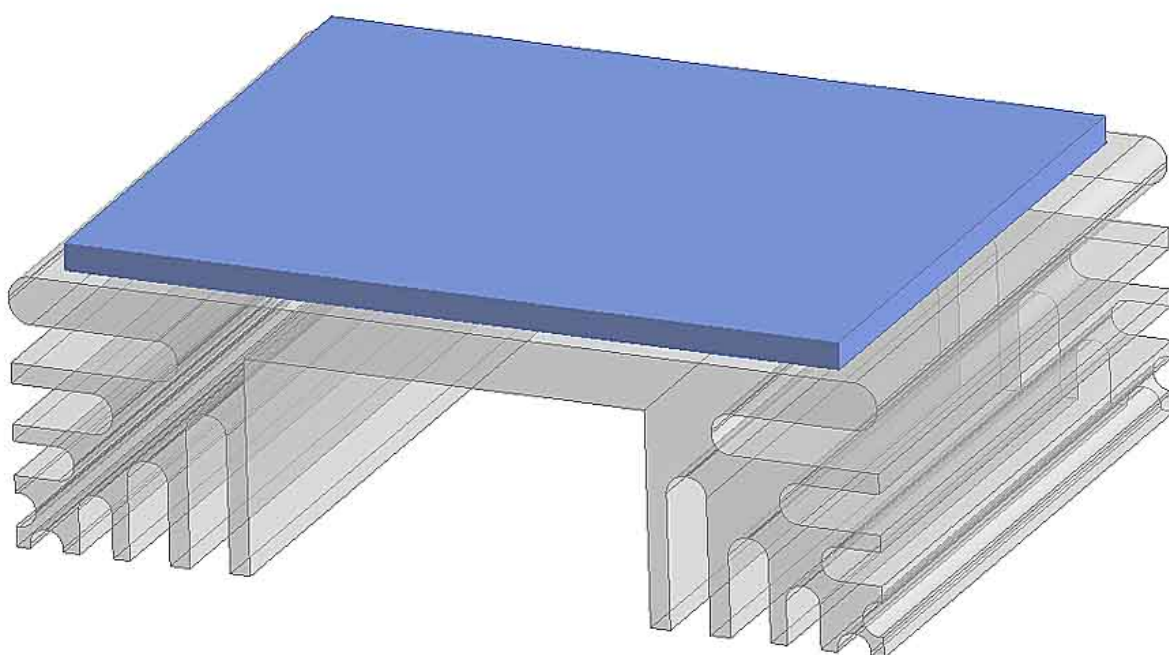
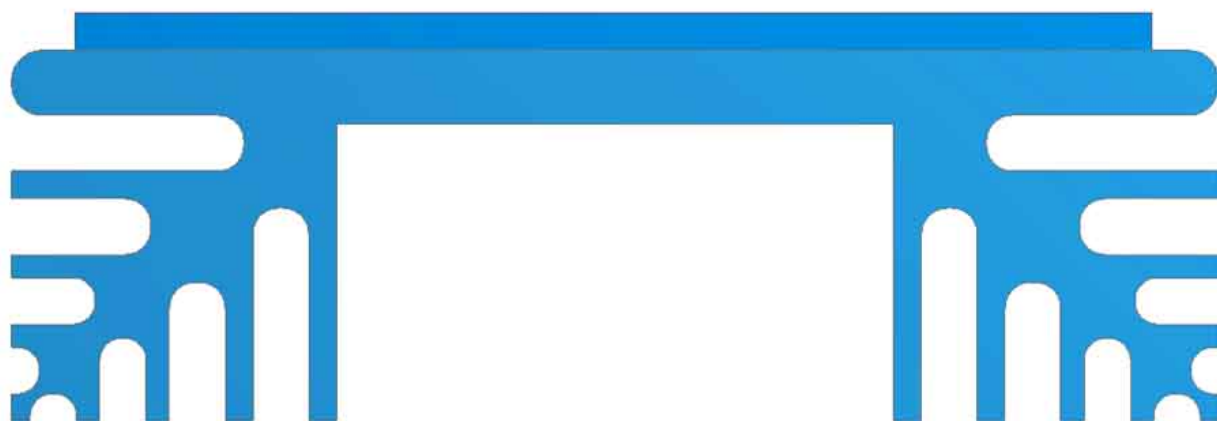
In a normal finned design, both conduction and convection are important. However in n situations where convection is low, such as a flat heat sinks (non-finned panel with low airflow), then radiative cooling can be the important factor as well. In any case, an important design factor is the surface properties. Black painted matte surfaces radiate with much higher efficiency than bare metals.



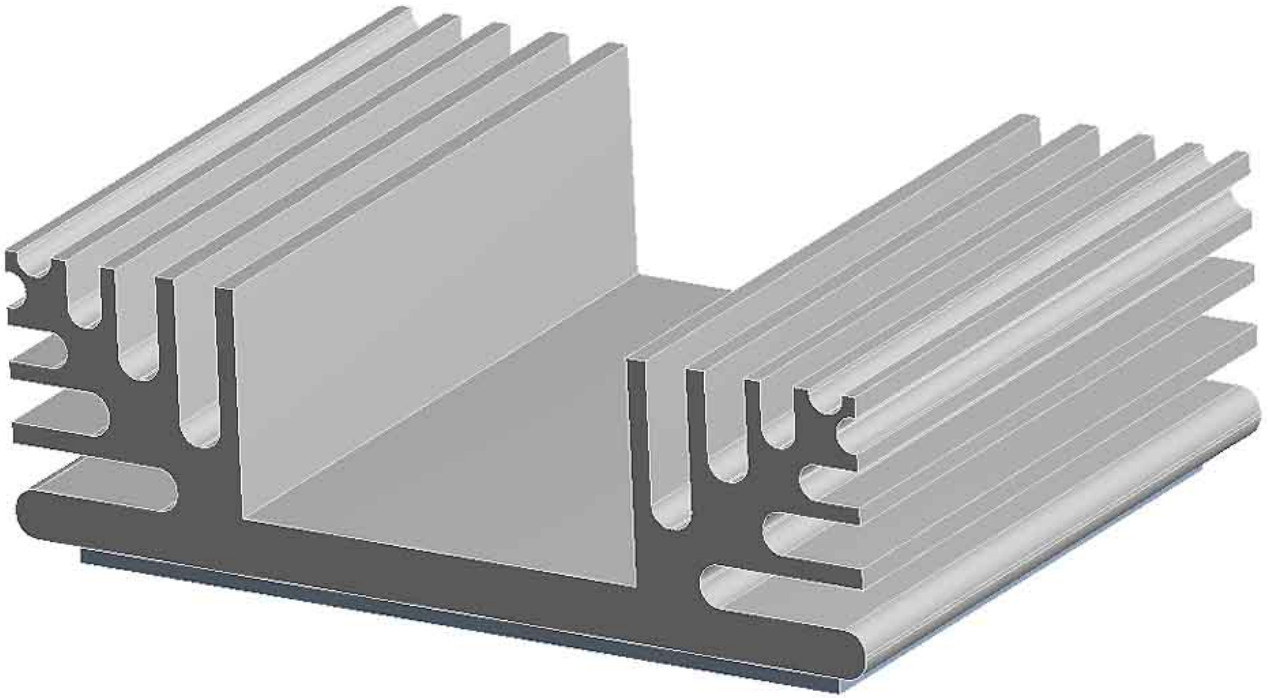
## Heat Sink Simulation

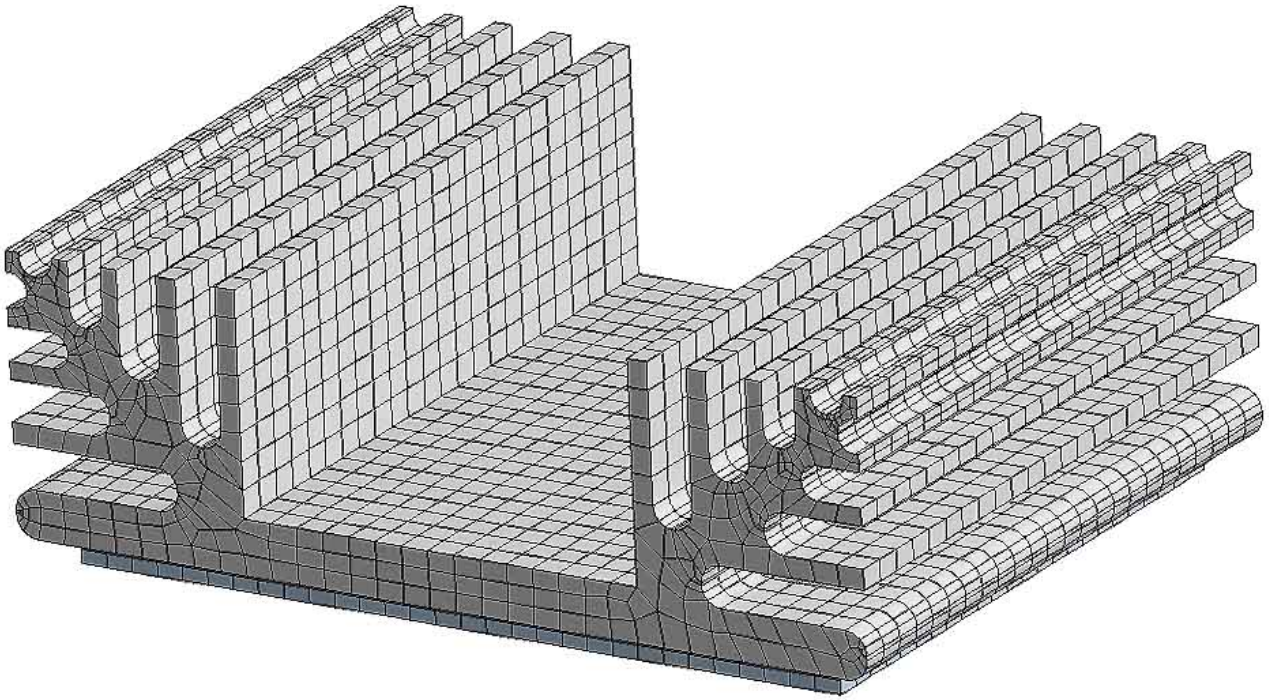
The simulation of a heat sink starts with the analysis of the design and model simplification. It's very important to know that the very small geometrical features does not play a significant role in the thermal analysis and the corresponding thermal management. The design process starts with the 2D sketching of the model and continues with the 3D design of the simplified model. The definitions of the proper material properties are the next step.





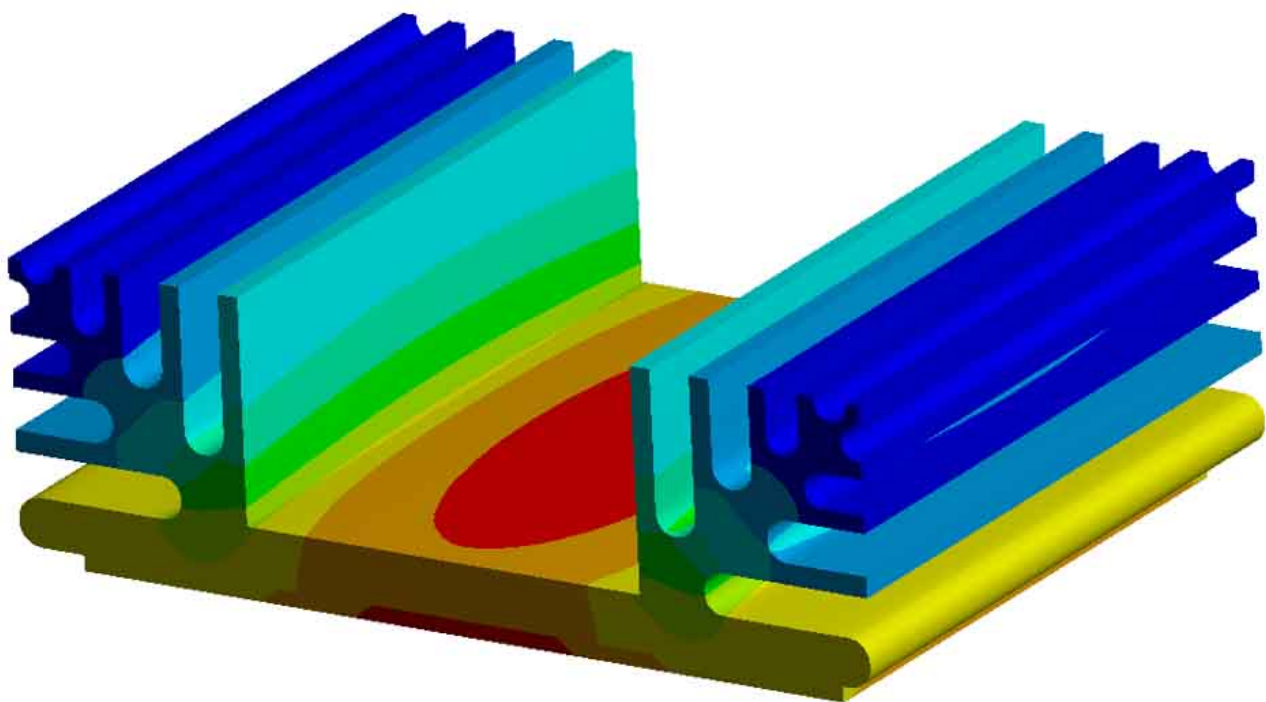
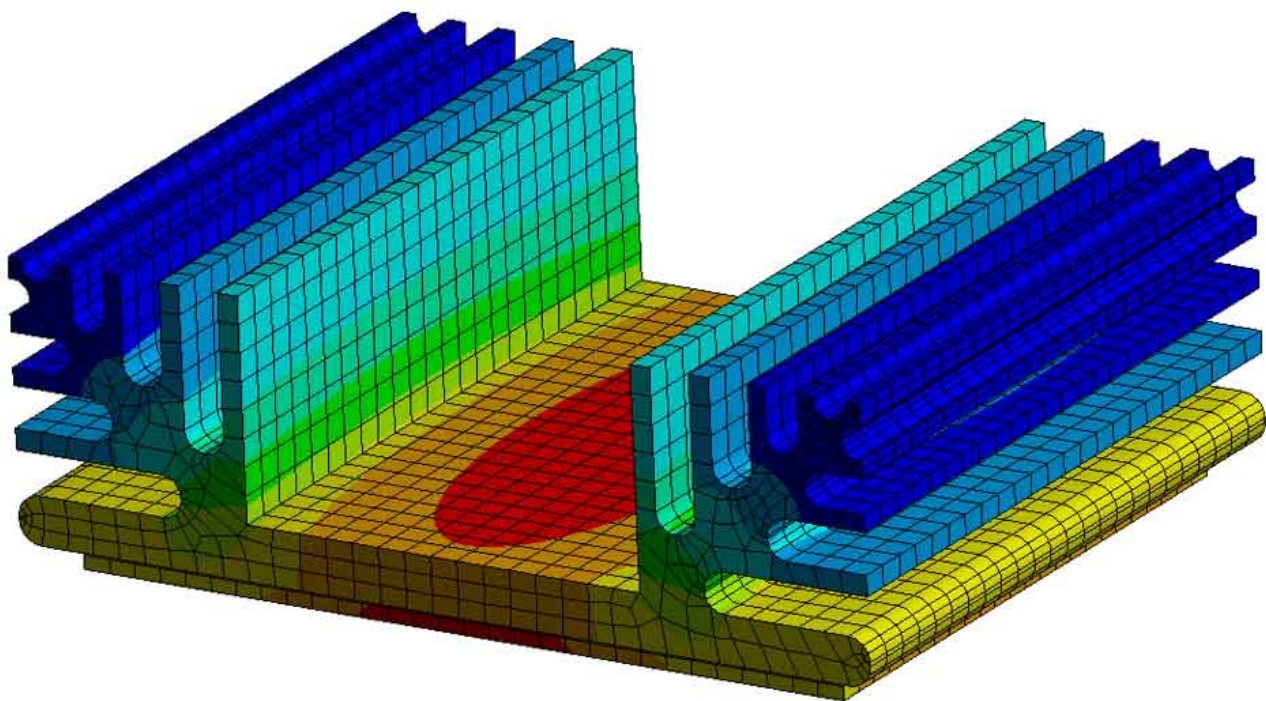
Meshing of the model is the next step. Afterwards, we come to the definition of the boundary conditions and load, and finally we can see the analysis of the results.



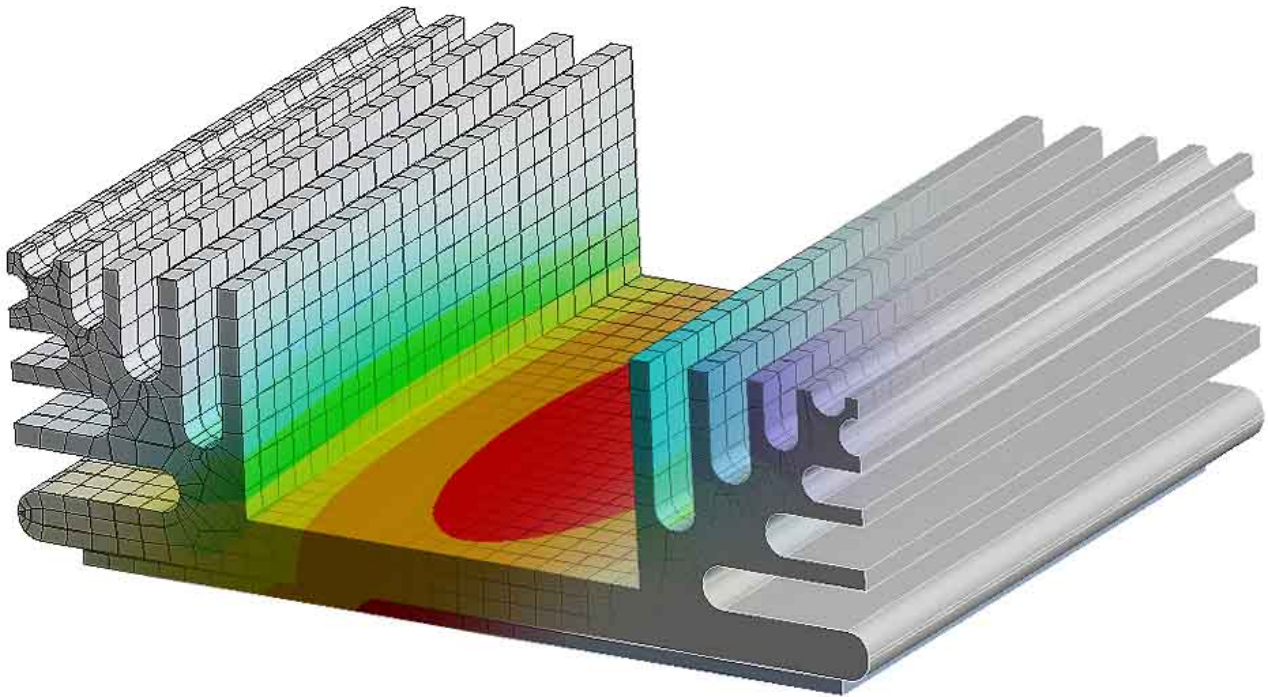


The final step is the analysis of the results. Here we mainly interested in the thermal distribution, which is the results of an steady state thermal analysis.





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## References

Thermal management and design optimization of heatsink for cooling performance improvement during transient heat generation, by A.m. Rhmani et. al. Energy Procedia 61 ( 2014 ) 1665 - 1668

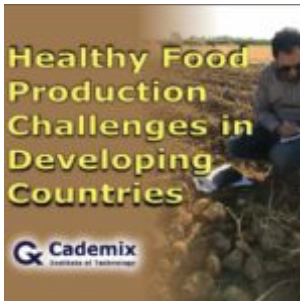
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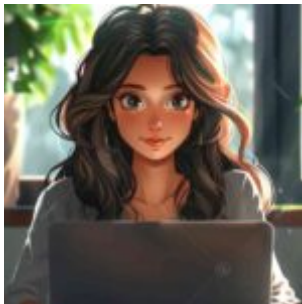
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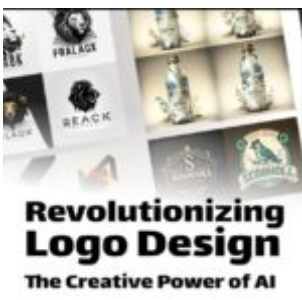
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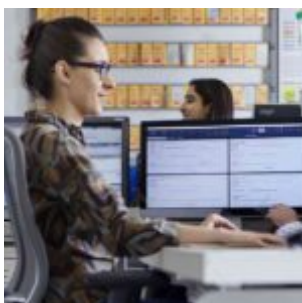




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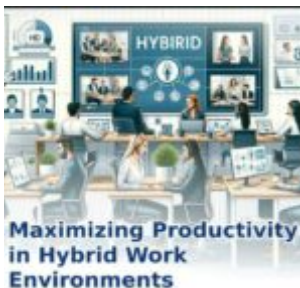
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