Modeling Of A Vapor Chamber Using COMSOL Multiphysics®

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Abstract

High power consumption chips have already become a major challenge for modern processors causing low thermal performances. Existing thermal solutions are not able to solve these high temperature issues efficiently. Two-phase cooling devices such as heat pipes and vapor chambers have proven to be among the most efficient active thermal solutions for electronics cooling.

In this work, we model in COMSOL Multiphysics® a small 3D vapor chamber used as a thermal solution for cooling microprocessors in laptops. We set up the computational frame by resorting to the heat pipe model of the Application Library. The steady state equations of conservation of fluid mechanics and heat transfer are implemented by using the Laminar Flow, Brinkmann Equations and Heat Transfer in Porous Media interfaces and the multiphysics couplings already available in the software. The computational model takes full advantage of both the CFD Module and the Heat Transfer Module, where these interfaces are located and of thermodynamic calculations for the vapor-liquid system using the Chemical Reaction Engineering Module.

The computational model is able to simulate the heat transfer process from the evaporator zone to the condenser at steady state. The results are validated with a real vapor chamber previously tested thermal laboratory from a third-party. The fit between the model and the experimental data reaches close to 0% error in predicting the transistor layer temperature, 2% error in predicting the temperature on the surface of the chamber, and about 4% error in computing the heat exchanger area.

Although we use a single input power and a fixed geometry, the model is useful to analyse real vapor chamber in case of changes in the properties of materials, working fluid or percentage of porosity of the wick medium, as long as the dimensions or proportions of its parts are not altered.

Reference

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Figures used in the abstract

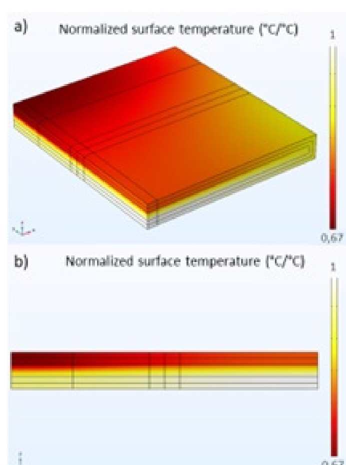

Figure 1 : Temperature contours of the vapor chamber’s external surface: a) isometric view; b) view of the cross section in the center of the chamber.