Energy Conversion and Management
Volume 206, 15 February 2020, 112485

A new design of liquid-cooled heat sink by altering the heat sink heat pipe application: Experimental approach and prediction via artificial neural network

Amin Taheri [a, 1], Mohammadamir Ghasemian Moghadam [a, 1], Majid Mohammadi [a], Mohammad Passandideh-Fard [a], Mohammad Sardarabadi [b]

Show more

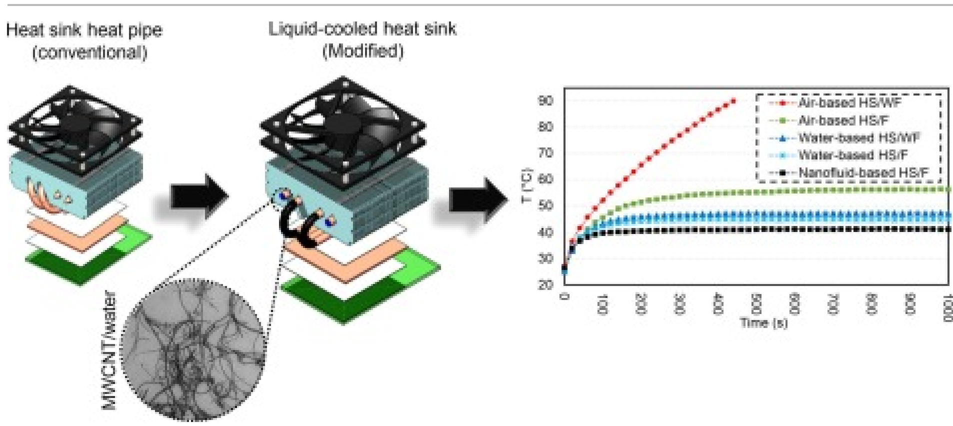
https://doi.org/10.1016/j.enconman.2020.112485

Highlights

- A new design of a liquid-based heat sink for thermal management was introduced.
- The performances of cooling modules were examined under constant/intermittent loads.
- Thermal resistance, energy efficiency, and transient PCB temperature were studied.
- Liquid-based heat sink was compared with conventional air-based heat sink heat pipe.
- Cooling ability of liquid-based heat sink was considerably higher than that of air-based heat sink.

heat sink heat pipe configuration, a new design of a liquid-based heat sink for the thermal management is presented. In this design, pure water with various flow rates ranged from 50 ml/min to 200 ml/min passes through a heat sink connected to a printed circuit board where heat fluxes of 4000 W/m^2–12,000 W/m^2 are applied. To further increase the performance of the liquid-based heat sink, pure water is replaced with two mass fractions of MWCNT/water nanofluid (0.15% and 0.3%). To compare the performance of the new design with that of the conventional heat sink, several important parameters are investigated. These parameters include the printed circuit board transient/steady temperature, the time required to reach steady-state condition, the average thermal resistance of the cooling module, the system cooling under intermittent loads, and the energy efficiency. At a heat flux of 4000 W/m^2, the printed circuit board steady-state temperature is reduced by 5.3 °C for the water-based heat sink compared to that of the conventional cooling module. When the heat flux is increased, the effect of the new cooling design in reducing the temperature of the printed circuit board is further pronounced. For example at a heat flux of 12,000 W/m^2, the printed circuit board steady-state temperature is reduced by 14.9 °C. The average thermal resistance of the water-based and nanofluid-based heat sinks at a flow rate of 100 ml/min compared with that of the air-based heat sink is decreased by approximately 0.28 °C/W and 0.34 °C/W, respectively. At the highest applied heat flux, when the MWCNT/water nanofluid with a mass fraction of 0.3% is used, the maximum energy efficiency is calculated to be about 59.2%. Finally, to predict the steady-state temperature of the printed circuit board using the introduced cooling module for other operating conditions, two artificial neural network methods (radial-basis function and multi-layer perceptron) are utilized.

Graphical abstract



Thermal resistance; Thermal management; Multiwall carbon nanotube; Printed circuit board; Artificial neural network

[1] These authors have equal contribution in this work.