Pengembangan pipa kalor berbasis terumbu karang dan nanofluida = Development of heat pipe based on coral and nanofluid

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Abstrak

[Peningkatan kinerja teknologi elektronik khususnya Central Processing Unit (CPU) yang disertai dengan pengecilan dimensi menghasilkan fluks kalor yang semakin besar. Peningkatan fluks kalor yang semakin tajam hingga 50 sampai dengan 100 W/cm2 memerlukan suatu pendingin yang mampu menyerap dan mengontrol fluks kalor yang dihasilkan tersebut sehingga CPU mampu bekerja secara handal dan umur pakai dari piranti tersebut menjadi lebih panjang. Tingginya fluks kalor yang dihasilkan mengakibatkan pendingin konvensional yang bekerja secara satu fasa kurang efektif untuk mengatasi permasalahan fluks kalor tersebut.
Pipa kalor merupakan alat pendingin pasif yang bekerja secara dua fasa, dimana sirkulasi fluida kerja hanya memanfaatkan gaya kapilaritas sebagai pompa kapiler. Struktur pori yang homogen, daya kapilaritas dan wettability yang tinggi merupakan beberapa persyaratan sumbu kapiler. Konduktivitas termal yang tinggi dari fluida kerja juga akan mampu meningkatkan kinerja pipa kalor. Sumbu kapiler yang umum digunakan dan biasanya memberikan kinerja yang baik terhadap kinerja pipa kalor adalah sumbu kapiler jenis sintered powder tembaga.
Sumbu kapiler jenis ini proses produksinya sangat sulit dan sangat susah untuk mampu menghasilkan struktur pori yang homogen. Sifat yang mudah teroksidasi juga mengakibatkan wettability dari sumbu kapiler menurun sehingga sifatnya menjadi hidrofobik, yang mengakibatkan kinerja pipa kalor menurun. Terumbu karang merupakan media berpori non logam yang memiliki struktur pori yang cukup homogen serta daya kapilaritas dan wettability yang tinggi.
Penelitian ini bertujuan untuk meningkatkan kinerja termal pipa kalor melalui pengintegrasian terumbu karang sebagai sumbu kapiler dan nanofluida sebagai fluida kerja. Penelitian dilakukan dengan melakukan pengujian pipa kalor dengan sumbu kapiler terumbu karang Tabulate yang memiliki diameter pori ± 52,949 μm dan sintered powder dengan diameter pori ± 60,704 μm yang juga dibandingkan dengan heatsink, heatsink fan dan termosipon. Pengujian dilakukan dengan kondisi pembebanan minimum dan maksimum dari prosesor yang dianalogikan melalui pelat simulator serta diujikan juga pada prosesor Pentium 4 2.4 GHz, dual core 925 3.0 GHz, core i.5 3.0 GHz dan core i.7 3.4 GHz. Nanofluida dibuat dari partikel nano Al2O3, TiO2 dan CuO dengan diameter 20 nm yang dicampur pada fluida dasar air dengan fraksi volume 0,1% vol sampai dengan 10% vol. Analisa CFD digunakan untuk menjelaskan sirkulasi aliran didalam pipa kalor.
Dari penelitian didapatkan penggunaan sumbu kapiler terumbu karang Tabulate dapat menurunkan hambatan termal 44% dengan meningkatkan koefisien perpindahan kalor12,13% dibandingkan dengan menggunakan sumbu kapiler sintered powder tembaga. Pada kondisi beban maksimal pipa kalor dengan sumbu kapiler terumbu karang Tabulate masing-masing dapat menurunkan suhu permukaan prosesor 36%, 38,19%, 35,29% dan 99,98% masingmasing untuk pendinginan pada prosesor core i.7, core i.5, dual core dan Pentium 4. Penggunaan nanofluida sebagai fluida kerja relatif lebih efektif pada fraksi volume rendah.

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The increasing performance of electronic device, especially in Central Processing Unit (CPU) is followed by smaller size dimension, which lead into higher heat flux production. A high heat flux production, which is 50 until 100 W/cm2 needs a cooling system that can absorb and control the heat flux till the CPU can perform greatly and has a long lifetime.Conventional cooling systems that work based on one-phase system are not effective to solve the problem that is caused by high heat flux production.
Heat pipe is a passive cooling device that work based on two-phase flow. Working fluid circulation only created by capillary force as capillary pump. Uniform pore structure,capillary force, and high wettability are some requirements for selecting wick. High thermal conductivity of working fluid will increase the performance of the heat pipe. Generally, sintered copper powder is used as wick to create a high performance heat pipe, but this kind of wick is very hard to be manufactured and non-uniform pores are created. Moreover, sintered copper powder is easy to be oxidized which lead into decreasing of wettability and become hydrophobic. Coral is a nonmetal material that has a uniform material, high capillarity force, and high wettability.
The purpose of this research is to elevate thermal performance of heat pipe through integrating coral material as wick and nanofluid as working fluid. Research is conducted by experimenting a coral tabulate wicked heat pipe with ± 52,949 μm pores diameter and a sintered copper powder wicked heat pipe with ± 60,704 μm. More comparison are done by using heat sink, heat sink fan, and thermosiphon. Heat load for this experiment use minimum load and maximum load from processor through simulator plate and Pentium 4 2.4 GHz processor, dual core 925 3.0 GHz, core i.5 3.0 GHz and core i.7 3.4 GHz. Nanofluid made from Al2O3, TiO2 and CuO with 20nm diameter. Those nano particles are mixed with water as based fluid with 0.1% until 10% as volume fraction. CFD analysis are used to explain fluid circulation inside the heat pipe.
From this research, it is concluded that the usage of coral tabulate can reduce thermal resistance as high as 44% with 12,13% increasing heat transfer coefficient compared to usage of sintered copper powder as wick. At full load, heat pipe with coral tabulate wick can decrease the processors surface temperature as 36%, 38,19%, 35,29% and 99,98% for core i.7, core i.5, dual core and Pentium 4 processor respectively. The usage of nanofluid as working fluid is relatively more effective at low volume fraction.;The increasing performance of electronic device, especially in Central Processing Unit
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