

INTISARI

Data center merupakan infrastruktur digital dengan konsumsi energi yang tinggi, di mana sebagian besar energi digunakan untuk sistem pendinginan. Keterbatasan metode air cooling dalam mengatasi peningkatan densitas panas komponen mendorong pengembangan teknologi pendinginan yang lebih efektif. Penelitian ini bertujuan membandingkan performa termal dan efisiensi energi sistem single-phase immersion cooling menggunakan fluida Shell S3X dengan sistem air cooling konvensional pada data center.

Penelitian dilakukan secara eksperimental menggunakan server Lenovo ThinkSystem SR250 V2 yang dilengkapi prosesor Intel Xeon E-2336 dan GPU NVIDIA RTX A400. Pengujian immersion cooling dilakukan pada variasi laju aliran 0,75; 1,25; 1,75; 2,25; dan 2,75 LPM dengan kondisi pembebanan CPU-only dan CPU+GPU. Data temperatur, konsumsi daya, dan pressure drop dianalisis untuk menentukan heat transfer coefficient, thermal resistance, PUE, dan CPI.

Hasil penelitian menunjukkan bahwa peningkatan laju aliran fluida mampu meningkatkan heat transfer coefficient dan menurunkan thermal resistance pada CPU maupun GPU. Dibandingkan air cooling, metode immersion cooling menghasilkan temperatur komponen yang lebih rendah serta performa perpindahan panas yang lebih baik. Dari sisi efisiensi energi, immersion cooling menghasilkan nilai PUE sebesar 1,09–1,27, lebih rendah dibandingkan air cooling yang memiliki nilai PUE sebesar 1,69. Hasil ini menunjukkan bahwa single-phase immersion cooling menggunakan cairan dielektrik Shell S3X memiliki potensi yang lebih baik dalam meningkatkan performa termal sekaligus menurunkan konsumsi energi sistem pendinginan data center.

Kata Kunci: *Immersion cooling, air cooling, GPU, CPU, PUE.*

ABSTRACT

Data centers are critical digital infrastructures with high energy consumption, a significant portion of which is used by cooling systems. The limitations of conventional air cooling in handling increasing heat densities have encouraged the development of more effective cooling technologies. This study aims to compare the thermal performance and energy efficiency of a single-phase immersion cooling system using Shell S3X dielectric fluid with a conventional air-cooling system.

Experiments were conducted using a Lenovo ThinkSystem SR250 V2 server equipped with an Intel Xeon E-2336 processor and an NVIDIA RTX A400 graphics processing unit. Immersion cooling tests were performed at flow rates of 0.75, 1.25, 1.75, 2.25, and 2.75 LPM under CPU-only and CPU+GPU loading conditions. Temperature, power consumption, and pressure drop data were analyzed to determine the heat transfer coefficient, thermal resistance, PUE, and CPI.

The results indicate that increasing the coolant flow rate enhances the heat transfer coefficient and reduces the thermal resistance of both the CPU and GPU. Compared with conventional air cooling, immersion cooling achieved lower component temperatures and superior heat transfer performance. In terms of energy efficiency, immersion cooling produced PUE values ranging from 1.09 to 1.27, which were lower than the air-cooling PUE value of 1.69. These findings demonstrate that single-phase immersion cooling using Shell S3X dielectric fluid has significant potential to improve thermal management while reducing cooling-related energy consumption in data center applications.

Keywords: Immersion cooling, air cooling, GPU, CPU, PUE.