High-efficient cooling for cloud computing system by refrigerant drip-feeding

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Abstract— We developed a sophisticated drip-feeding cooling system that efficiently cools high thermal density servers using multiprocessor implementation of CPUs or general-purpose computing on graphics processing units (GPUs) for high-performance computing such as machine learning. Fluorine inert liquid and Silicone oil were used as refrigerants. The refrigerant is pumped from the lower refrigerant reservoir up to the upper refrigerant reservoir, and refrigerant drip-feeding is demonstrated from the reservoir by natural fall onto the CPU (or GPU) board. This system achieves cooling heat by around 15 kW per rack at a power usage efficiency below 1.02. By comparing to the conventional immersion system, total power consumption is reduced, and also the floor loading is significantly reduced below 500kg/m2. By using newly developed compact UPS, pump for rifting refrigerant up to the reservoir keeps working for around 90 min even in case of power failure. As a result, such high performance system can be placed even on an office floor.

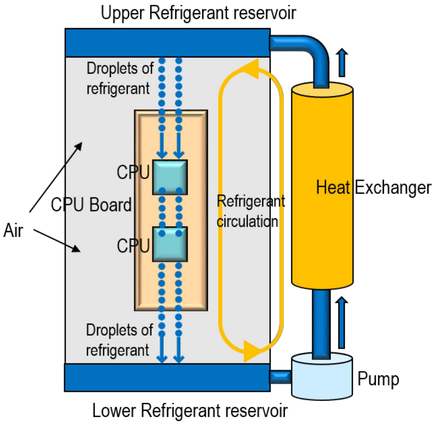


Fig.1 Experimental apparatus for refrigerant drip-feeding, with refrigerant quantity by 1/5 to 1/10 that of conventional immersion cooling system.

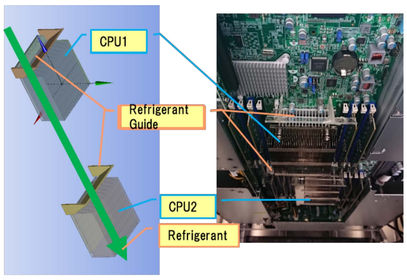
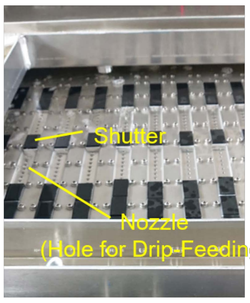
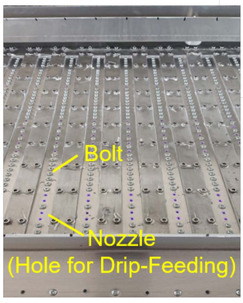


Fig.2 Snapshot of CPU board and refrigerant flow.



Type A: Nozzle Closed by Shutter



Type B: Nozzle Closed by Bolt

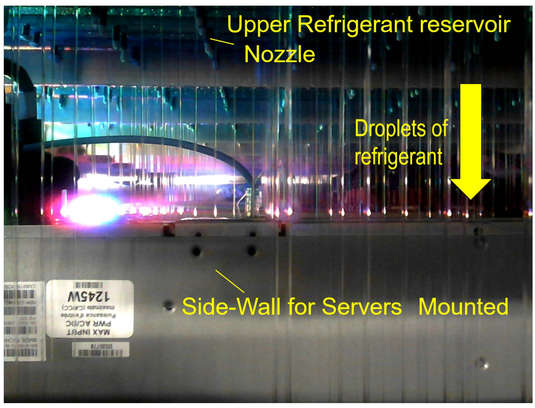


Fig.3 Snapshots of nozzle arranged on the bottom of the upper refrigerant reservoir and drip-feeding from the upper refrigerant reservoir.

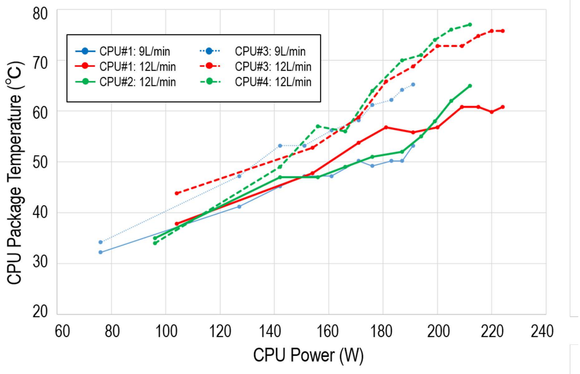


Fig.3 Typical relationship between CPU power applied and CPU temperature, for several CPUs. The parameter is refrigerant flow rate.

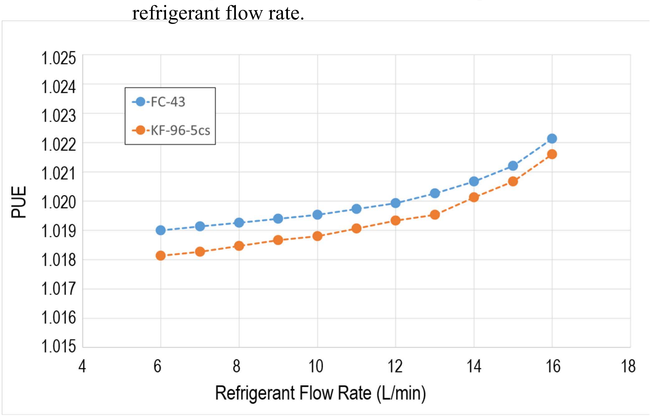


Fig.4 Relationships between refrigerant drip-feeding flow rate and PUE. The refrigerants used are silicone Oil 5cs and Fluoro Carbon(Fluorinert) FC43.

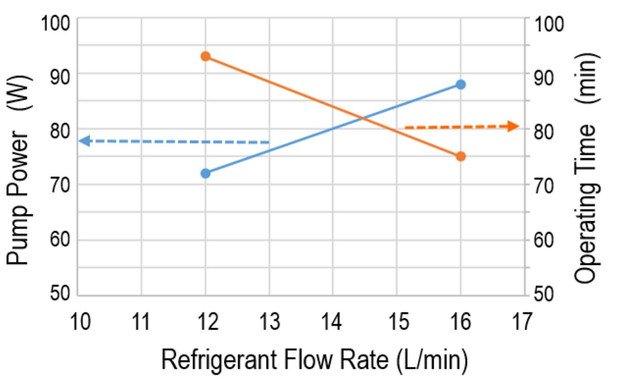


Fig.5 Relationships between refrigerant drip-feeding flow rate (FC43) and pump power, and operating time in case of power failure by using UPS .

Summary

1. We developed a high-efficient drip-feeding cooling system for cloud computing system. In this system, HPCs and GPUs with high heat density are cooled with high efficiency.
2. The weight of the system can be greatly reduced compared with the conventional bathtub-type immersion-cooling system.
3. The targeted cooling performance of 15 kW per rack and PUE of below 1.02 were demonstrated. Also, by using compact UPS developed, around 90 min operation for refrigerant pumping up can be demonstrated even with power failure.
4. As a result, the developed drip-feeding cooling system exhibits promising potential for being applied to high heat-generation server systems in offices, laboratories, and data center, of course.

Acknowledgement

This study was supported by the Ministry of Environment in Japan. The drip-feeding system is operated by NTT-East Corporation. The heat exchange system for cooling water was developed by Takasago Thermal Engineering Co., Ltd. The perfluorocarbon structured refrigerants (Fluorinert) were provided by the 3M Company.

References

[1] Kazuhiro Matsuda, Morito Matsuoka and Yoichiro Miyake, “Proposal of cooling system for high performance computing by drip-feeding cooling”, ASHRAE Winter Conference, 2018.