DESIGN OF EXPERIMENTS FOR RACK-LEVEL FLOW BALANCE AND THERMAL STABILITY IN LIQUID-COOLED L11 RACKS

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Zoom Link:
https://binghamton.zoom.us/j/92968686361?pwd=VfFUoAzmmtJdatXS1LtwTXjGyaz7oU.1&jst=2

Abstract

Liquid cooling has become essential for high-density AI/ML server racks, where traditional air-based methods can no longer manage rising thermal loads. This thesis presents a structured methodology to evaluate the hydraulic and thermal performance of a full-scale Technology Cooling Loop (TCL) used in manufacturing and validating liquid-cooled L11 racks. Using Design of Experiments (DOE) principles, controlled hydraulic and thermal tests were performed to identify how Coolant Distribution Unit (CDU) operating conditions, manifold behaviour, and station-level flow characteristics influence overall system performance.

Hydraulic validation established that the TCL exhibits linear and predictable pressure–flow behaviour, maintains uniform flow across all twelve stations, and consistently meets the minimum flow requirements for L11 rack testing. No pressure ripple or instability was observed during setpoint changes or dynamic station transitions.

Thermal validation using a 500-kW load bank demonstrated stable supply-temperature regulation, predictable temperature rise across stations, and fast recovery during load ramps and station activation/shutdown events. Even under stepped high-load conditions and with a fluctuating dummy rack, the TCL maintained temperature stability and station isolation.

Overall, the results confirm that the TCL is capable of delivering reliable hydraulic balance and thermal performance for large-scale liquid-cooled rack validation. The methodology developed in this work provides a practical, repeatable framework for optimizing cooling-loop operation in industrial data-center manufacturing environments.