Supercritical CO2 Experimental Cart for Cooling AI Data Center Chipsets

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https://infinityturbine.com/infinity-turbine-supercritical-co2-experimental-cart-for-ai-data-center-cooling-technologies.html

An overview of using a supercritical CO_2 test cart to explore advanced cooling technologies for AI data center chipsets and server racks, including ejector cooling, cascade systems, Joule Thomson effect cooling, and chiller-style configurations, with benefits for small-scale experimentation before large-scale deployment.

This webpage QR code

PDF Version of the webpage (maximum 10 pages)

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Introduction

The rapid growth of artificial intelligence workloads has pushed data centers to the limits of existing cooling technologies. High-performance GPUs and server racks generate massive amounts of heat that must be dissipated efficiently and reliably. Supercritical carbon dioxide is emerging as a promising fluid for next-generation cooling. A cart-mounted experimental test system provides a safe and modular platform for evaluating small-scale concepts before scaling up to production-ready designs.

Cooling Applications with Supercritical CO_2

Ejector Cooling

Supercritical CO_2 ejectors use pressure differentials to generate local zones of cooling. These systems can be compact, with no moving parts, making them attractive for immersion cooling or chip-level cooling where simplicity and reliability are essential.

Cascade Cooling Systems

By staging multiple CO_2 cooling loops, cascade systems can reach very low temperatures or provide distributed cooling across multiple rack zones. A test cart allows controlled trials of cascading pressure stages and heat exchangers.

Joule Thomson Effect Cooling

The Joule Thomson effect, in which expanding CO_2 through a throttling device causes rapid cooling, is well-suited for chip-level spot cooling. Experimental setups can test miniature throttling valves, orifices, and expansion paths to measure achievable cooling power.

CO_2 as a Traditional Chiller

Supercritical CO_2 can also function in conventional chiller-style systems, replacing water or refrigerants. On a small cart system, researchers can evaluate CO_2 condenser and evaporator designs, pressure management strategies, and overall energy efficiency before scaling to large data center chillers.

Additional Possibilities

Spray or jet impingement cooling directly onto chip surfaces.
Two-phase cooling loops that leverage CO_2 phase changes for high heat flux removal.
Hybrid CO_2 and liquid metal systems for extreme GPU cooling requirements.

Advantages of a Supercritical CO_2 Test Cart