TECH OFFER

Topology Optimization Platform for Thermal-Fluid Systems

KEY INFORMATION

TECHNOLOGY CATEGORY:
Energy - Thermal Power System
Infocomm - Computer Simulation & Modeling

TECHNOLOGY READINESS LEVEL (TRL): TRL5
COUNTRY: JAPAN
ID NUMBER: TO175400

OVERVIEW

Heat management has become a critical bottleneck in advanced industries such as electric vehicles, aerospace, data centers, and next-generation electronics. Traditional design processes rely heavily on expert intuition and repetitive simulation, requiring weeks to explore only a narrow design space. This results in high costs, limited performance improvements, and significant delays in bringing products to market.

The presented technology introduces a thermal-fluid topology optimization engine that autonomously generates optimal structures for cooling and fluid management. Unlike conventional parameter studies, this approach explores the entire design space and discovers novel, high-performance solutions beyond human intuition. By integrating multi-fidelity modeling and high-accuracy simulations with lightweight surrogate models, the technology reduces design time from 20-30 days to just 3-5 days, while improving cooling efficiency by more than 30%.

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By combining breakthrough computational science with industrial applicability, this technology provides a next-generation design foundation for sectors where thermal performance is a decisive factor for competitiveness. Potential adoptors of this technology includes manufacturers facing urgent thermal challenges: automotive OEMs, aerospace suppliers, electronics and semiconductor companies, and data center operators. These industries demand shorter design cycles, reduced CO_2 emissions, and higher product reliability.

The technology owner is seeking to collaborate with design and manufacturing companies from different industries looking to optimise heat transfer in thermal-fluid systems. The technology owner is also open to partnerships with Computer-Aided Engineering software providers who are interested to intergrate this technology into a platform.

TECHNOLOGY FEATURES & SPECIFICATIONS

The technology consists of a cloud-based topology optimization engine specialized for thermal-fluid systems. At its core is a proprietary multifidelity algorithm that dynamically integrates high-precision computational fluid dynamics (CFD) models with low-cost physics-based surrogate models. This hybrid approach achieves a dramatic reduction in computation time while maintaining design accuracy. By enabling radical improvements in performance, manufacturability, and energy efficiency, this technology provides a foundation for disruptive products across multiple global markets.

Key features include:

- **Rapid design generation and optimisation:** Reduces thermal-fluid design cycles from 20–30 days to 3–5 days.
- **High-performance solutions:** Demonstrated >30% improvement in cooling efficiency compared to conventional designs.
- **Design for manufacturing:** System is designed to incorporate manufacturing constraints directly into the optimization process. Munufacturing methods include additive manufacturing, injection molding, and machining processes.
- **CAD/CAE integration:** Seamless export of optimized geometries into standard CAD models, ensuring manufacturability.
- **Scalable computing:** Built for cloud deployment, supporting parallel processing and multi-user environments.

POTENTIAL APPLICATIONS

This technology has broad applicability across industries where thermal management and fluid design are critical performance bottlenecks. Ideal collaboration partners span multiple points in the industrial value chain.

- **Automotive & Mobility:** Electric vehicles require highly efficient battery cooling and powertrain thermal management. By reducing thermal resistance and enabling compact, lightweight cooling systems, this technology directly enhances driving range, charging speed, and safety.
- **Aerospace & Aviation:** Lightweight structures and high heat resistance are essential for aircraft and spacecraft. Optimized cooling channels and thermal-fluid systems improve reliability while reducing weight and fuel consumption.
- **Electronics & Semiconductors:** As devices become smaller and more powerful, overheating is a major risk. This technology can be applied to smartphones, laptops and high-density servers, enabling higher performance with lower energy loss.
- **Data Centers:** With data demand exploding, cooling efficiency is the key cost driver. Optimized liquid-cooling solutions derived from this platform can reduce energy consumption and CO2 emissions while improving reliability.
- **Industrial Equipment & Energy Systems:** From robotics and heat exchangers to renewable energy storage, the technology enables more durable, efficient, and sustainable designs.
- **Software vendors and CAE providers:** are potential partners for integration into broader engineering toolchains.

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- **Others:** Products that can be marketed based on this technology include high-efficiency heat sinks, advanced cooling plates for EV batteries, liquid-cooled data center modules, aerospace thermal management components, and next-generation industrial heat exchangers.

MARKET TRENDS & OPPORTUNITIES

The market potential for advanced thermal-fluid design technologies is vast and rapidly expanding. The global CFD (Computational Fluid Dynamics) software market is projected to grow from USD 2.6 billion in 2023 to USD 5.3 billion by 2033, with a CAGR of 7.2%. Within this, thermal management for electric vehicle batteries alone is estimated at USD 3.7 billion in 2024, expected to grow at 12.6% CAGR through 2034. Similarly, aerospace, electronics, and data center industries are facing exponential demand for high-performance cooling solutions, driven by electrification, miniaturization, and rising energy costs.

UNIQUE VALUE PROPOSITION

Existing technologies struggle with speed, scalability, and design freedom. By overcoming these barriers, this technology positions itself as a game-changing design platform. Its value lies not only in potential cost reduction and improved energy efficiency but also in enabling new categories of products from ultra-fast EV charging systems to liquid-cooled high-density data centers. It reduces reliance on expert intuition and empowers manufacturers to achieve breakthrough performance, shorter time-to-market, and lower carbon footprints.

- **Design Freedom:** The ability to explore entire design spaces and generate non-intuitive, high-performance solutions.
- **Improved Heat Exchange Efficiency:** Can potentially achieve >30% improvement in cooling performance compared to conventional design methods.
- **Speed:** By leveraging multi-fidelity topology optimization, it combines high-accuracy models with lightweight surrogate simulations. This enables unparalleled turnaround time for industrial-scale thermal-fluid optimization by speeding up design cycles by >90%.
- **Manufacturability:** Optimised designs can be directly fabricated using standard industrial and manufacturing processes with the option of direct export to CAD/CAE.

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