Self-adaptive fins for local control of heat extraction capacity

UniSCool
Universal Smart Cooling

Revolution through GREEN digitalization

David Beberide[1,2], Montse Vilarrubí[1,2], Jaume Camarasa[2], Desideri Regany[2], David Sancho[1], Manel Ibáñez[2] and Jérôme Barrau[1,2]

[1]Universal Smart Cooling SL (UniSCool)
[2]University of Lleida (UdI)

Lleida, Spain   david.beberide@uniscool.tech   https://uniscool.tech/

OCP FUTURE TECHNOLOGIES SYMPOSIUM
29 APRIL, 2025
DUBLIN, IRELAND

I. Introduction

Nowadays, with the **irruption of AI** among other cutting-edge technologies, the need for data processing has sharply increased. For this reason, the **energy consumed** in **data centres** is a **major concern**, and **40%** of their **consumption** is directly related to **cooling[1]**.

UniSCool is a **direct-to-chip liquid cooling** company with a **patented adaptive heat sink** technology that **improves energy efficiency by up to 60%** compared to traditional solutions like microchannels and jet impingement. By dynamically adjusting to thermal loads, our innovation ensures optimal **temperature uniformity.**

Our technology has been **validated in real-world conditions**, undergoing **five months of testing in a data center** to assess its reliability and efficiency. Additionally, we have developed an **In-Server solution**, where the entire **hydraulic circuit is integrated within the server**, allowing for a **compact and highly efficient cooling solution**.

[1]M. Azarifar, M. Arik, and J. Y. Chang, "Liquid cooling of data centers: A necessity facing challenges," Appl Therm Eng, vol. 247, p. 123112, Jun. 2024, doi: 10.1016/J.APPLTHERMALENG.2024.123112.

II. Working Principle

The technology developed is based on **self-adaptive fins**, which **dynamically adjust** to **optimize heat extraction** in response to **changing thermal loads in time and space**.

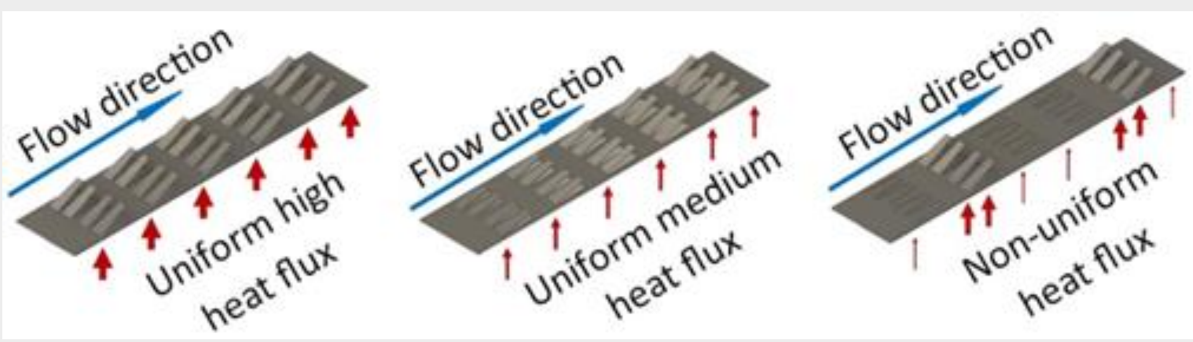

Fig. 1. Working principle of the cooling channel with self-adaptive fins.

The fins use phase change materials to **self-activate** based on temperature, **without external excitation**. Their flow-disturbing capability **enhances heat extraction only under high cooling demands**; otherwise, they remain flat.

III. Results

We aim to **evaluate the performance** of our **cooling solution** by analyzing its impact on **thermal resistance**—specifically, by assessing the reduction in **temperature gradient** achieved with the **self-adaptive fins** and the improvement in the **convective heat transfer coefficient**—as well as its effect on **pressure drop**, to determine the potential **energy savings**. The test is performed on a 1 mm channel height with a sample of 5 rows with 4 fins each (Fig. 1). This design is compared to a flat channel.

Boundary conditions		
Flow rate	Inlet temperature	Heat loads
285 ml/min	62 °C	3 and 9 W/cm²

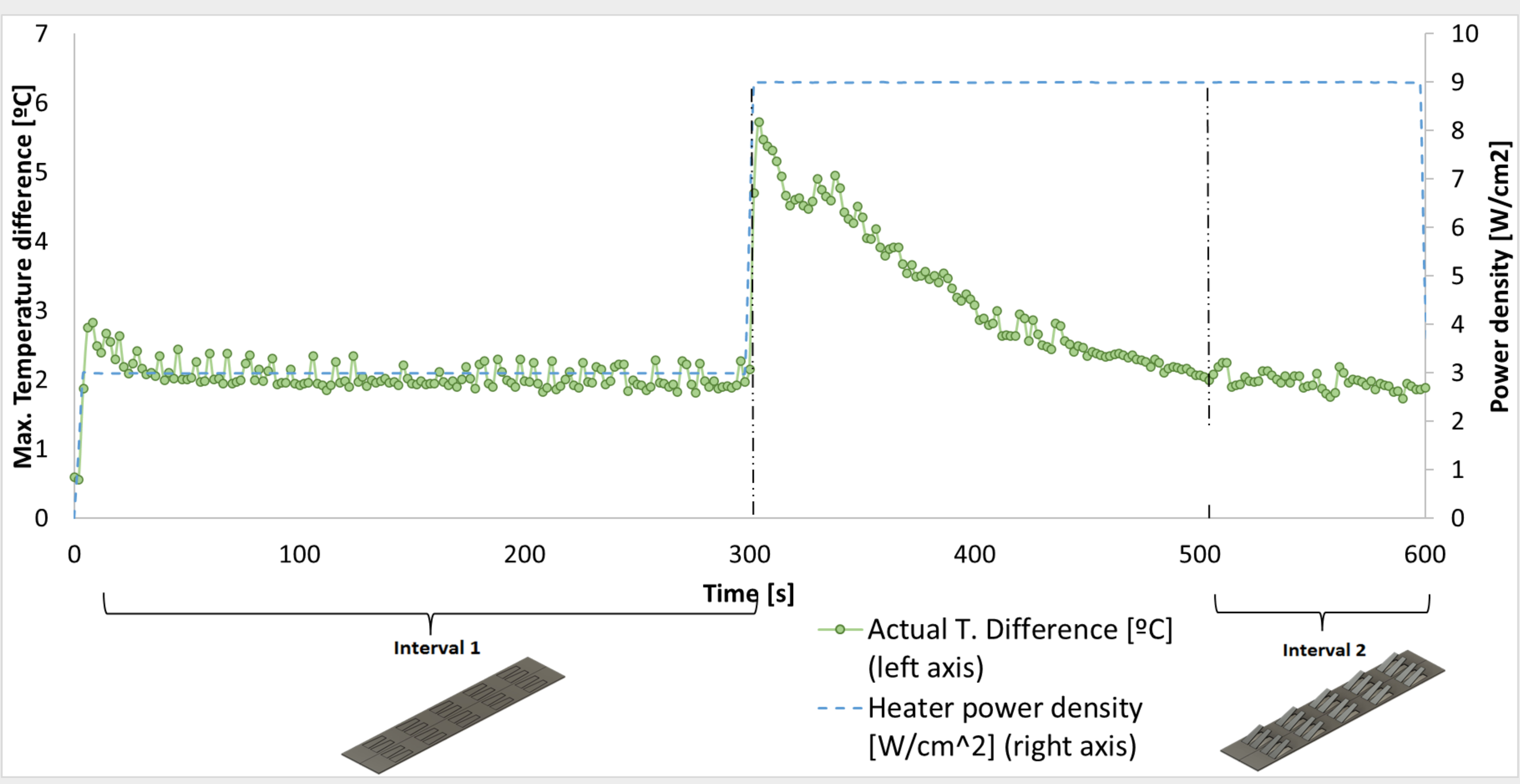

Fig. 2. Experimental maximum temperature difference along the channel with swlf-adaptive fins when applying heat loads.

The device with the self-adaptive fins **manages to maintain a temperature gradient of 2°C**, which is much smaller than that obtained with the flat channel, which is **5,4°C** (Fig. 2).

In terms of heat transfer, at low heat flux (interval 1), self-adaptive fins stay flat, matching the convection coefficient of a plain channel. Under high heat flux (interval 2), fins rise to 30% of the channel height, **resulting in a heat transfer enhancement about 50 % higher** (Fig. 3).

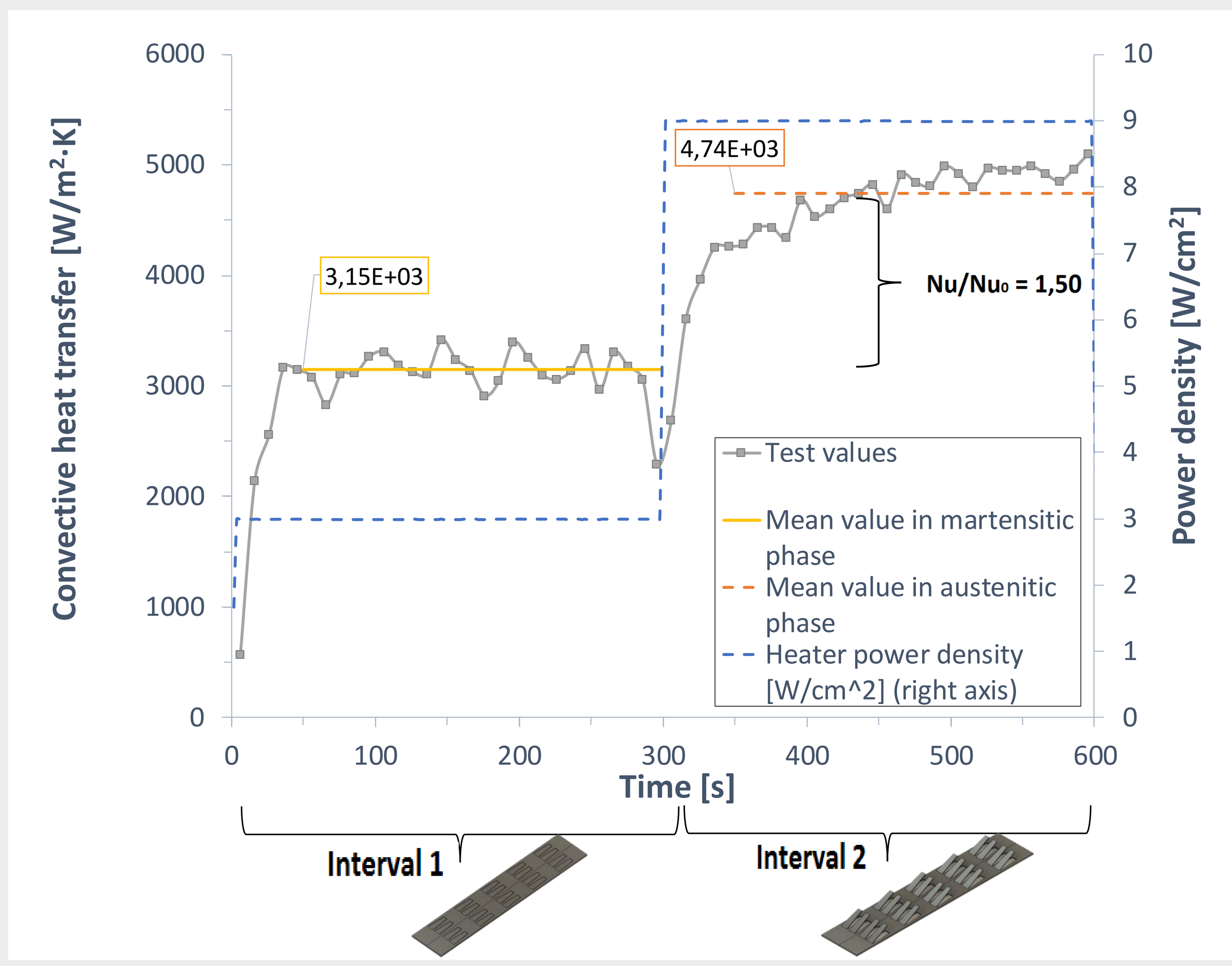

Fig. 3. Experimental convective heat transfer coefficient for a channel with self-adaptive fins in martensitic and austenitic phases.

Self-adaptive fins **raise only during high thermal loads**, minimizing pressure drop in the cooling channel. This **reduces pumping power** needs, **lowering pressure drop by 60%** in low thermal load scenarios compared to static fins.

IV. Conclusions

1. Self-adaptive fins to improve **uniform wall temperature by over 60%** under varying heat flux distributions.
2. Self-adaptive fins **enhance heat transfer efficiency by 50%** under high heat flux, significantly **reducing thermal resistance**.
3. The **pressure drop is reduced by 60%** when there is no heat extraction demand, with the **consequent reduction of pumping power**.

Grant PID2021-123634OB-I00 funded by MCIN/AEI/ 10.13039/501100011033 and ERDF A way of making Europe. This project was developed under the NEOTEC 2023 program (CIN/373/2022), funded by CDTI, from the Spanish Ministry of Science, Innovation and Universities and the European Union NextGenerationEU. David Beberide also wants to acknowledge the grant Doctorados Industriales convocatoria 2022 (DIN2022-012868) funded by MCIU/AEI/10.13039/501100011033.

MINISTERIO DE CIENCIA E INNOVACIÓN
UNIÓN EUROPEA
FONDO EUROPEO DE DESARROLLO REGIONAL "Una manera de hacer Europa"
AGENCIA ESTATAL DE INVESTIGACIÓN
CDTI
Plan de Recuperación, Transformación y Resiliencia
Financiado por la Unión Europea NextGenerationEU