porecool
porous cooling systems

UNIQUE WORLDWIDE

METAHYBRID Systems
BEST OF Solution in R&D
Germany

OPENPORE Components
Innovation of the Year 2022
Germany

METAKER® Surface
Lightweight Technology Award
Germany

BEFORE | **AFTER**

up to 70%
smaller and lighter

NEW TECHNOLOGY FOR POWERFUL, LIGHTWEIGHT AND COMPACT COOLING SYSTEMS

COOLING SYSTEMS MADE OF POROUS ALUMINUM

Think differently. Cool better.

CONVENTIONAL SOLUTIONS AT THE PERFORMANCE LIMIT

Excess heat in electronics, technology and industry requires efficient cooling. Heat sinks and heat exchangers, manufactured using different processes, ensure performance, durability and sustainability.

After many years of optimization, the possibilities for improving the heat dissipation of conventional manufacturing processes have largely been exhausted. Further adaptations are associated with high costs, limited benefits and numerous disadvantages:

- larger and heavier heat sinks and heat exchangers,
- higher material and energy consumption with a negative environmental balance,
- increasing costs for development, production and logistics,
- limited integration into mobile and compact systems,
- low flexibility for individualization and modularization.

PORECOOL TECHNOLOGY IMPROVES YOUR PRODUCTS

PORECOOL cooling systems unlock new engineering knowledge and potentials beyond conventional technologies.

- higher performance,
- lower weight and smaller size,
- better product designs and more innovations,
- better sustainability.

NEW MATERIAL CLASS FOR BETTER THERMAL MANAGEMENT

PORECOOL cooling systems are made from open-pored chill cast aluminum. This new lightweight class of materials differs substantially from foamed, sintered or 3D-printed materials and has many new attractive features for high-performance thermal management:

- pore sizes adjustable for every requirement,
- up to 8x higher thermal conductivity vs. aluminum foam,
- up to 20x higher compressive strength vs. aluminum foam,
- up to 10x greater specific surface area vs. profile heat sinks,
- up to 70% less weight compared to profile heat sinks,
- conventional processing and fastening technology,
- economical for many applications in small and large quantities
- many other previously unknown, advantageous properties.

NEW OPTIMIZATION POTENTIALS FOR THERMAL SYSTEMS

Efficiency. Weight. Dimensions. Mechanical and thermal load capacity. Multifunctionality. Integration. Lifetime. Acoustics. Air / water flows. Filtration. Circuit board layouts. Device designs. Sustainability.

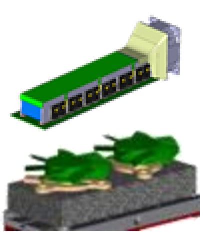
POSSIBLE APPLICATIONS FOR THERMAL REDESIGN

Air cooling. Water cooling. Evaporators. Coondensers. Thermally stressed machines. Housings. Heat storages. Energy storages. Solar thermal collectors. Exhaust systems. Catalytic converters. Thermally stressed plastic parts etc.

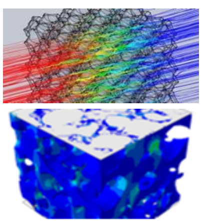
And many options for integrating additional features: filtration, sound absorption, dust protection, splash protection, flame protection, shock absorption, homogeneous media distribution, and more.

OUR OFFER | Quick potential forecast. Feasibility study. Product development. Manufacturing.

Development

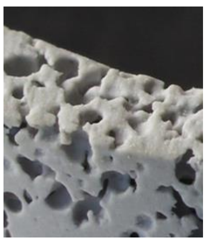


Simulation



Manufacturing

Functional surfaces



Multifunctionality

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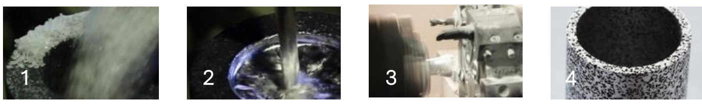
NEW MATERIAL CLASS FOR THERMAL MANAGEMENT

Open-pore cast aluminum - a material that is permeable to water, air and light - is produced using a simple gravity die casting process by pouring NaCl spacers (table salt) without the use of harmful substances. The resulting components have been used by more than 400 industrial customers in 12 countries for many years.

In 2022, it was awarded the ThinKing lightweight construction prize by the state of Baden-Württemberg.

MANUFACTURING PROCESS

The manufacturing process involves casting molten aluminum (2) into a mold filled with NaCl (1). The placeholders form interconnected cavities that allow aluminum to penetrate. After solidification, the component is mechanically processed (3), and the salt is rinsed out with water (4).



Advantages and Possibilities:

- over 700 pore variants (various sizes, graded, selective),
- monomaterial hybrids (combination of solid and porous areas),
- multimaterial systems with polymers and/or metals,
- high design flexibility and adjustable pore sizes,
- compatibility with standard joining and manufacturing processes.

SUSTAINABILITY

In contrast to other processes, the production of open-cell cast aluminum does not require powder materials, propellants, binders, galvanic coatings, foaming systems, furnaces, acid baths and many other environmentally harmful materials and systems.

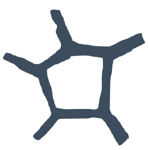
As the recycled material - secondary aluminum - is used as standard, it can easily be returned to the recycling loop at the end of the component's life. The aluminum chips are remelted and reused. The salt solutions are used for industrial water treatment.

NEW MECHANICAL, THERMAL, ACOUSTIC AND OTHER MATERIAL PROPERTIES

The open-cell cast structure with a new type of pore morphology offers many new, specifically adjustable combinations of structural, mechanical, fluid mechanical, thermal, acoustic, decorative, technological and ecological properties unknown from other materials.

COMPARISON OF OPEN-PORE MICROSTRUCTURES

Open-cell cast Aluminum



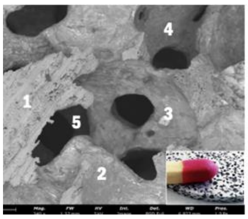
Aluminum foam

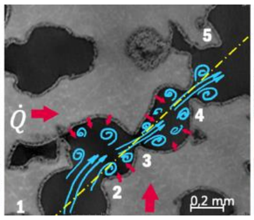
Sintered metal

BETTER THERMAL MANAGEMENT WITH PORECOOL COOLING SYSTEMS

PORECOOL cooling systems enable innovative approaches to thermal management, unlocking new technical, economic, and environmental potential. Cooling efficiency depends on various factors, including material properties, heat transfer surface area, geometry, surface structure, flow parameters, and thermal conductivity.

Traditional open-cell aluminum foams have been considered suitable for convective heat transfer due to their high specific surface area and





permeability. However, PORECOOL cooling systems go a step further, offering entirely new possibilities for design, performance optimization, and integration—far beyond the limits of conventional solutions:

- novel multimodal pore morphology with flexibly adjustable pore sizes in the micro and macro range,
- low weight, very good thermal conductivity and extremely large surface area,
- very good permeability for gases and fluids,
- complex, oscillating, quasi microencapsulated microflows,
- very good heat transfer coefficient,
- better flow acoustics and directional independence of the cooling circuit,
- great design freedom for heat sinks, flow circuits, circuit board layouts, fan position, housings, devices.
- high integration capability in installation spaces and housings with any joining technology,
- production as mono and multi-material hybrids made of metals and/or polymers for thermal, mechanical, fluid mechanical, acoustic and decorative multifunctionality.

CUSTOMER FEEDBACKS

It was very interesting. We definitely need to try out your ideas on test samples. (M. M. / R&D Hardware, Automotive Tier-1).

The idea of having a heat sink the size of a bar of chocolate is really very tempting. We want to order the test samples. (Dr. M. H. / CEO, Manufacturer of power electronics),

We see an opportunity to strategically open up new markets with our products. Let us produce the test samples. (A. H. / CTO, Heat exchanger manufacturer).

We have completed the tests. The results are promising. (M. E. / Senior R&D Engineer, Manufacturer of power electronics).

The EMPB samples have been successfully tested. We initially need 1,000 units for the series launch. (P. K. / Purchasing, plant manufacturer).

We are looking for a manufacturable solution for our heat exchanger. Your technology gives us many new and interesting approaches. (D.D. / Product owner, Heat pump manufacturer).

CUSTMERS OF OUR TECHNOLOGY PROTFOLIO

Audi ABB amazon BMTS BOSCH DAF DAIMLER faurecia
FESTO Fraunhofer GRAMMER handtmann HILTI HOPPE Yanfeng
KIT LAMY MAGNA MAHLE MAN maxon novem PORSCHE
swoboda TDK Valeo VW voxeljet Webasto ZF

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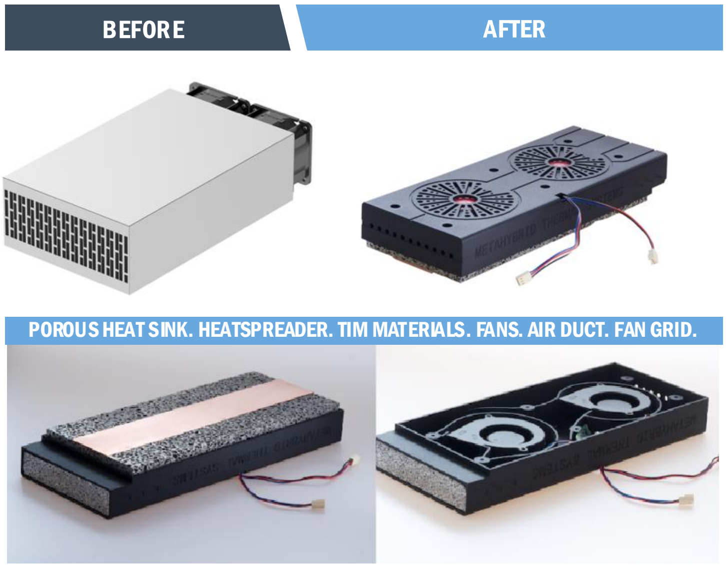


CHALLENGE

A manufacturer of electronic power amplifiers relies on conventional aluminum profile heat sinks, which make up about 30% of the device's total weight. As power dissipation increases in new equipment generations, larger heat sinks are required, complicating system design and integration. The growing size and weight of these heat sinks lead to higher storage, shipping, and assembly costs, making traditional cooling solutions less viable. To address these challenges, the focus has shifted toward developing lighter, more compact systems that maintain efficient heat dissipation. In search of innovative technologies, the manufacturer discovered PORECOOL cooling systems, offering a promising alternative to conventional solutions.

SOLUTION APPROACH

In a technology workshop, the problem and solution spaces were discussed, hypotheses developed and the objective for the first feasibility study defined.

The objectives.

- focus on design-to-cost for prototypes and series production.
- waiver of many possible optimisation potentials.
- at least similar performance like conventional finned heat sink with less dimensions or weight.

The solution approach.

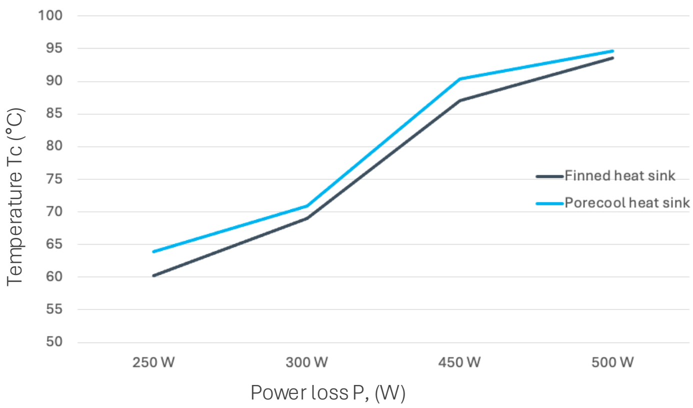
- concept design with price indication for series production.
- DoE samples and tests concept, so that maximum information is obtained with minimum test effort.
- physical tests on the product, without laboratory measurements or digital simulations.
- direct comparison of performance and price with conventional finned heat sink.

PORECOOL SOLUTION

- comparable, optionally optimizable cooling performance,
- 64% smaller and 69% lighter,
- 60% better heat transfer coefficient,
- 30% smaller specific surface area,
- simpler design, no tooling costs,
- better integration into mobile and compact devices,
- a high degree of customization and modularity,
- better air circulation in the system,
- better CO_2 balance,
- release for series production.

TEMPERATURE AT THE COLLECTOR OF A SEMICONDUCTOR (Tc)

Temperature diagram shows measured values from the series finned heat sink and PORECOOL prototype. Several options are available for improvement if required.



OUR OFFER

1. Consultation call.

Your project, product, challenge and our possible support.

2. Quick Potential Assessment

NDA. Your product, challenges and goals. Our solution approaches and potential forecast. Next steps for feasibility study.

3. Feasibility study.

Pysical and / or digital prototypes. Validation. Optimization.

4. Product development

Final design. Procurement.

5. Production Ramp-up & Series Manufacturing

Made in Germany. EMPB. Ramp-up. Delivery.

For more information, videos and other products please visit our websites:

www.porecool.com www.openpore.com www.automoteam.com

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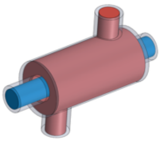
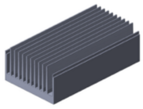
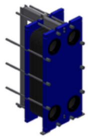
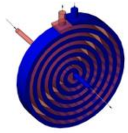
COMPARISON WITH OTHER TYPES OF HEAT EXCHANGERS

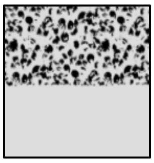
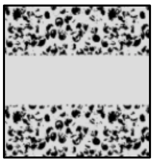
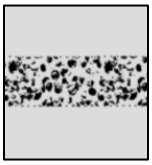
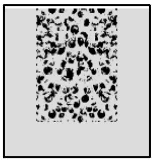
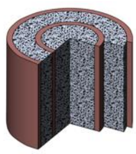
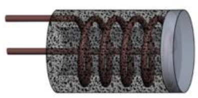
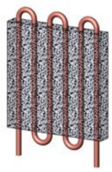
PORECOOL heat exchangers demonstrate significant superiority over traditional shell and tube, plate or finned solutions. They provide higher intensity of heat exchange, allow to significantly reduce the size of the equipment while maintaining the thermal capacity, although they are characterized by slightly higher hydraulic losses (by 8-10%). Their application is economically justified due to increased efficiency and possibility of use in a wide range of systems - from air conditioning to heat supply of industrial facilities.

For demonstration purposes, let us consider several examples of traditional heat exchangers according to their specific surface area (m^2/m^3)

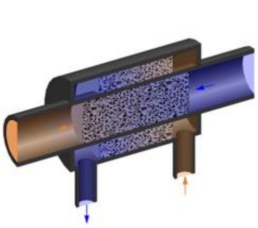
PORECOOL	Pipe in pipe	Spiral in the tube	Shell and tubes	Fins	Plates	Spiral
						
1.200 – 12.500	10 - 100	100 – 1.000	100 – 1.000	200 - 700	10 – 6.000	10 - 80

HYBRID PORECOL SYSTEMS

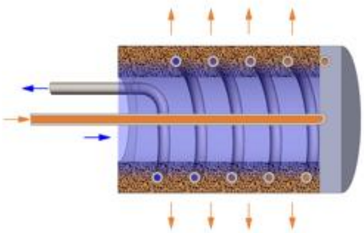
Hybrid systems are a significant advantage of PORECOOL technology because they eliminate thermal resistance at the point of contact between porous and solid metal parts. The possible options for fabricating parts with a solid part are listed below. Tubes, plates, and profiles made of aluminum, copper, and stainless steel can be integrated into PORECOOL systems.

Al – Al Hybrid	Al-Al Hybrid	Al-Al Hybrid	Al-Al Hybrid	Al - Copper	Al - Stainless steel	Al - Al
						

POSSIBLE APPLICATIONS FOR HEAT EXCANGERS



Pipe in pipe. Increasing the heat transfer surface.



Spiral in a tube. Increasing the heat removal surface of the tube.

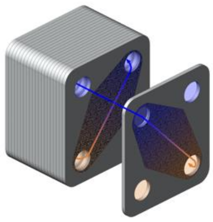
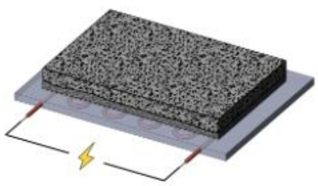


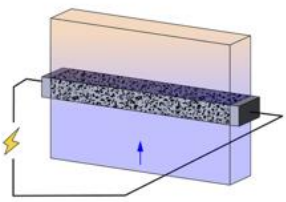
Plate heat exchanger. Cold and hot circuits are designed as a hybrid system

POSSIBLE APPLICATIONS FOR HEAT EXCANGERS

Flow-through air heater. Heat distribution from the heating elements through porous aluminum



Electric evaporator. The heating element is cast in solid aluminum. 2 layers of porous aluminum: fine-porous on the bottom and large-porous on the top



Electric flow heater. Porous aluminum allows the current to flow well and is used as a heating element.

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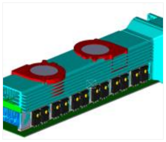
PORECOOL DEVELOPMENT SERVICES

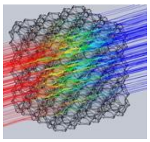
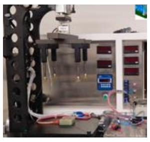
Porous aluminum is an innovative material with unique mechanical, thermal, acoustic, and technological properties. It requires specialized expertise and new ways of thinking to unlock its full potential. At the same time, it opens up new solutions for challenges that are difficult, costly, or even impossible to address with conventional technologies.

Efficient cooling systems are a critical factor in power electronics. Numerous challenges must be overcome, including limited space, flexible installation positions, high power densities, and demanding environmental conditions such as vibrations and humidity. Conventional cooling technologies often reach their limits in these scenarios.

PORECOOL cooling systems represent a new generation of high-performance heat sinks made from porous aluminum. This technology combines maximum cooling efficiency with minimal weight and a compact design.

With our development services, we support you from the initial feasibility analysis through simulation and prototyping to production readiness. Our systematic approach allows you to focus entirely on your product development while we provide customized thermal management solutions tailored to your specific needs.



1. Consultation Call

The first step is a non-binding, free consultation, where we discuss your product, requirements, and goals. You will receive an initial assessment of whether and to what extent PORECOOL cooling systems can optimize your thermal management or help you achieve your technical and economic objectives.

2. Quick Potential Assessment

At this stage, we analyze the framework conditions of your application to determine the suitability of PORECOOL cooling systems for your thermal management needs. We focus on:

- Available space, performance, weight, and thermal requirements.
- Material variants and design concepts.
- Potential thermal performance improvements and optimization opportunities.

After signing a non-disclosure agreement (NDA), we receive CAD data of your current cooling system, a detailed problem description, and specific requirements for the new solution.

Depending on your objectives, we evaluate various scenarios:

- Performance enhancement within the existing space: What thermal improvements are realistically achievable?
- Optimization of size and weight: If no increase in cooling performance is needed, how compact can the new design be compared to the current solution?
- Maximum performance with an optimized layout: What performance levels are possible if system adjustments are made, and what changes would be necessary?

The results are discussed in an online meeting, where we jointly define the scope of the first feasibility study to achieve a quick and cost-effective proof of functionality with minimal effort.

3. Feasibility Study

To validate the optimal cooling system design, we offer multiple approaches:

- Digital prototypes: Simulation of various designs for precise concept evaluation
- Physical prototypes: Development and testing of real-world samples
- Hybrid approach: Combining both methods for accelerated optimization

For each application, we select the most suitable material variants from hundreds of available options. Since porous aluminum is not included in commercial CFD software, custom-developed digital material models are required. These models are specifically adapted for each application and verified using physical material samples in our laboratory. Only through correlation between simulation and real-world test data can we achieve precise calibration and reliable predictions of heat dissipation.

For physical prototypes, we follow a hybrid proof of concept approach:

- Reference measurements in our laboratory: Comparative measurements between the customer's system and our prototypes provide reliable reference values and allow us to offer well-founded recommendations for independent testing. This minimizes misinterpretations and unrealistic expectations.

- Customer testing under real operating conditions: The customer receives identical test samples along with our recommendations for independent evaluation in their real-world environment.

After analyzing the test results, we discuss the findings together and define the next steps for a targeted system optimization.

4. Product Development

Following successful prototype testing, the next step is optimization for series production. During the DFM (Design for Manufacturing) phase, the design is refined to ensure efficient large-scale manufacturing.

The result is a production-ready cooling system, with all production documentation and testing procedures finalized in collaboration with the customer. This phase ensures that the design is fully optimized for the manufacturing process while meeting both technological and economic requirements.

5. Production Ramp-up & Series Manufacturing

The final phase involves scaling up production, including:

- Pilot production: Small batches for final validation before mass production
- Production validation: Ensuring consistent quality
- Full-scale manufacturing in Germany through our partner – a specialized heat sink manufacturer

Thanks to our structured approach, the transition from development to production is seamless and efficient.

WHY CHOOSE PORECOOL COOLING SYSTEMS?

Tailor-made designs for maximum efficiency.

Superior performance at minimal weight and size.

Innovative products with better design and system integration.

Cost-efficient modular cooling systems and economic mass production.

Sustainable material and cooling concepts for future-proof solutions.

START YOUR PORECOOL JOURNEY TODAY!

Let's revolutionize your thermal management together – speak with our experts and explore the possibilities of PORECOOL!

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TECHNOLOGY IMPRESSIONS

Air cooling

Plastic cooling

Multimaterial hybrids


Lightweight tools

Technical components

Molding tools


Water cooling


Shock absorber


Sensor protection


Gas distribution


Filtration

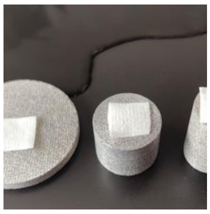

Muffler


Architecture


Light panels


Lamps

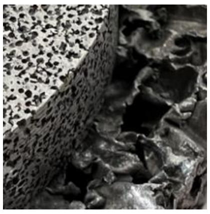

Design


Capillaries


Splash protection


Alternative for sintered bronze


Alternative for sintered steel


Alternative for aluminum foam

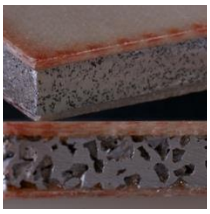

Vacuum tables


Vacuum transport

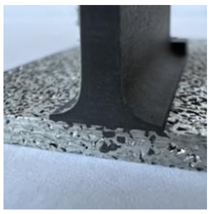

Functional surfaces

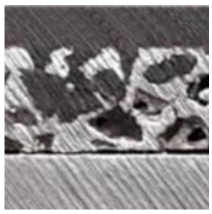

Monomaterial hybrids I


Monomaterial hybrids II


Glas fiber hybrids


Carbon fiber hybrids


Injection molding hybrids

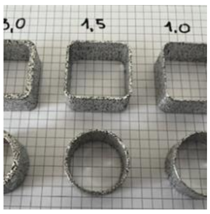

Thermoforming hybrids


Ultrasonic welding

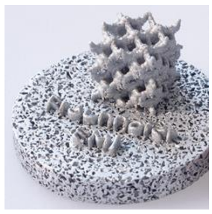

Gluing and pressing


Thread


Fastenings



Machining


3D printing hybrids

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