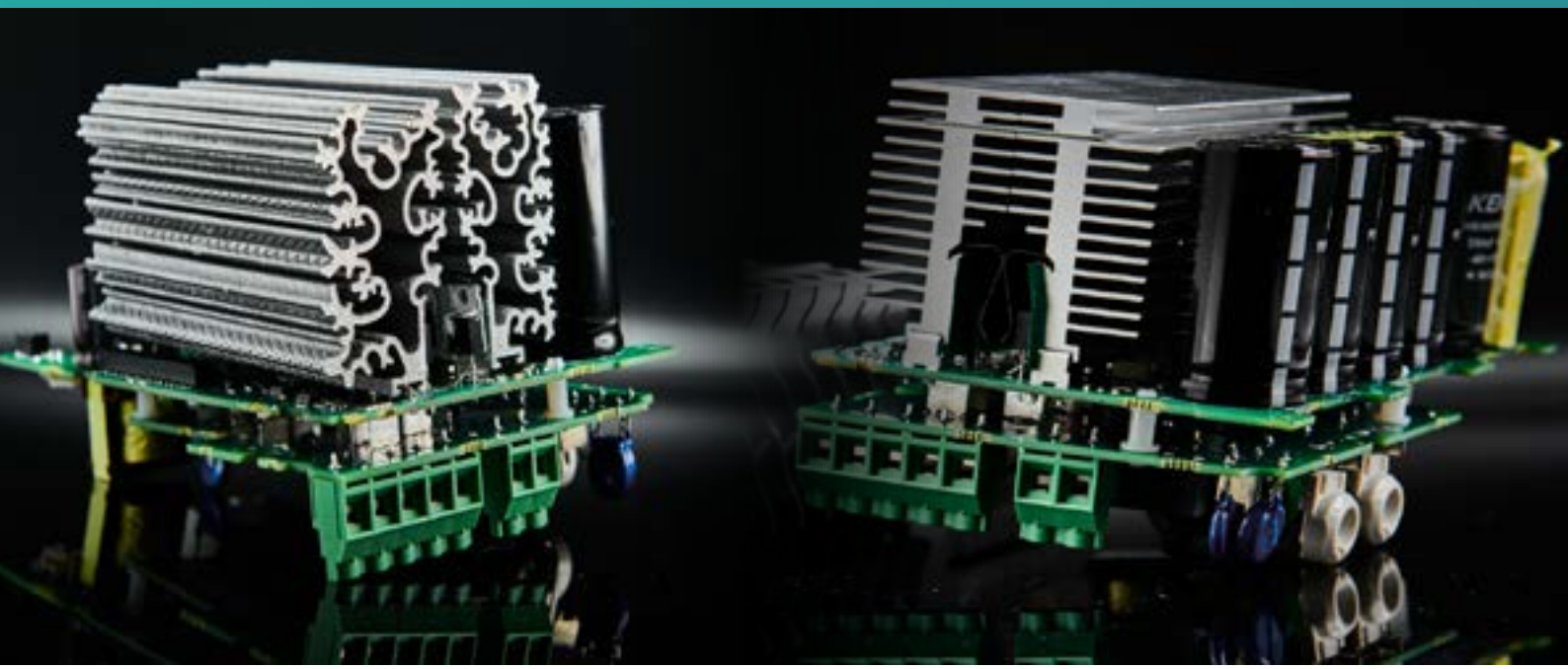
Market Sector:
AUTOMOTIVE / POWER ELECTRONICS
AEROSPACE

Technology Theme:
ELECTRIFICATION / DIGITAL ENGINEERING
ADDITIVE MANUFACTURING

OPTIMISING THE PERFORMANCE OF HEAT SINKS THROUGH THE USE OF HIGH-VALUE DESIGN TOOLS



Utilising thermal-fluid topology optimisation and additive manufacturing to address the issues of performance, miniaturisation, and weight in traditional heat sinks

> Managing the heat generated by electronic components has always been an important element of electronic design. Through this project, we have been able to demonstrate how we can use intelligent thermal designs optimised by advanced design and manufacturing techniques to prevent heat-related failures, increasing the life expectancy of the systems, and reducing emitted noise, energy consumption, cost and time-to-market.
>
> **Hassan Akhtar, Advanced Research Engineer – The MTC**

THE CHALLENGE

There has been a seismic shift towards electrification and a significant increase in the use of power electronics as the UK looks to achieve the Government's net zero target by 2050.

Given the global transition from combustion engines to electric motor propulsion, industries such as automotive, aerospace and the rail sector are continually trying to find ways of improving the power density for their existing systems.

The challenge for the MTC was to use high-value design tools such as topology optimisation to optimise an off-the-shelf heat sink, such as those found in a variable speed drive. The aim was to improve the heat transfer away from the electronic components, therefore allowing for enhanced thermal performance and a reduction in the overall weight.

MTC'S SOLUTION

To address the challenge, engineers at the MTC utilised high-value design tools that could achieve the desired performance benefits for the proof-of-concept demonstrator.

First, the team reverse engineered the initial design using traditional CAD software. COMSOL Multiphysics® topology optimisation was then used to remove the fins on the cross-sectional shape of the heat sink and optimised with a dendritic design to allow for a greater flow of air. Additional design work was conducted, applying a fractal approach to mimic the behaviour seen in nature and extend upon the output of the optimisation.

Further design changes were made to fully utilise the additive manufacturing design freedom. This included the addition of dimples to improve the surface texturing of the heat sink which further improved the heat transfer with a reduction in the pressure drop.

THE OUTCOME

The MTC has used thermal-fluid optimisation and additive manufacturing to produce a high-performance heat sink. These high-value design and manufacturing techniques have allowed for the proposed design to benefit from a 20% improvement in thermal performance with a 6% reduction in overall mass compared to the original design.

The result is a design workflow that could be applied to a variety of thermal management systems for numerous sectors where a cooling unit is significantly important for passive cooling.

> This project is a great example of the power of collaboration here at the MTC. By working together and utilising the expertise across technology themes, we've been able to deliver a demonstrator that could have a significant impact on UK manufacturing. More specifically, our industrial members in the motorsport and aerospace industries will benefit by using this novel design methodology and will see marked gains through the enhancement in the thermal performance of their power electronics systems.
>
> **Steve Nesbitt, Chief Technologist – MTC**

BENEFITS TO INDUSTRY

Through being able to utilise state-of-the-art technologies, coupled with teams of experienced researchers and engineers, this project has shown how high-value design can positively impact UK manufacturing in industries where electrification is going to be essential to their future development.

It has also demonstrated that topology optimisation as a process can direct engineers to highly optimised designs that will reduce the time taken for the design process, save money in already costly processes, and provide lighter units with better performance and an increased power density.

This project demonstrates how the MTC can work with clients on novel design methodologies, to uncover the art of the possible, in sectors where thermal management is integral for improved performance and reliability.

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