Innovative COoling system for embedded Power Electronics

Berichterstattung

Projektinformationen

ICOPE

ID Finanzhilfevereinbarung: 755556

Projektwebsite

DOI
10.3030/755556

Projekt abgeschlossen

EK-Unterschriftsdatum
23 Mai 2017

Startdatum
1 Juni 2017

Enddatum
31 August 2020

Finanziert unter
SOCIETAL CHALLENGES - Smart, Green And Integrated Transport

Gesamtkosten
€ 943 507,75

EU-Beitrag
€ 786 165,25

Koordiniert durch
UNIVERSITAT POLITECNICA DE CATALUNYA
Spain

Periodic Reporting for period 3 - ICOPE (Innovative COoling system for embedded Power Electronics)

Berichtszeitraum: 2019-10-01 bis 2020-08-31

Zusammenfassung vom Kontext und den Gesamtzielen des Projekts

The main issue being addressed in ICOPE project is the design of innovative and efficient air cooled heat sinks to cool the power electronics modules that are a key component of the more electrical aircraft power management centre design.
This topic is of importance for the society because the improvement of air-cooled solutions in front of liquid cooled or twophase cooled units, implies the reduction of weight in the electric components of any application, together with a simplification of the system that at the end increase its reliability.
If one considers the huge penetration of electric solutions in the field of transport and in the renewable energy field ,it remains even more clear that any improvement in the performance/weight/reliability of the corresponding cooling solutions is a key factor for further developments.
Then, the overall objective of the project is the development of innovative air-cooled heat sinks, by the combination of two new advanced thermal materials: Annealed Pyrolitic Graphite (APG) and Metal Matrix Composites (MMC). APG is integrated to reduce the temperature gradients in the base plate of the heat sink. MMC aluminium graphite improves the aluminium features (thermal conductivity, thermal diffusivity, and thermal expansion coefficient).
The integration of the heat sinks into a power management bay (airflow management) is also an important objective, as the success of the new heat sinks also relies on a good platform to be integrated in the aircraft.
At the end of the project the main objectives of the project at a heat sink level have been accomplished, as having designed, manufactured and tested successfully new innovative air cooled heat sinks covering the requirements in terms of temperature level, pressure drop and weight. The units have also accomplished salt-fog tests and vibration tests (C1 DO-160G curve).
This is true for the first set of units (with APG, Stage A), and also for the second set (APG+MMC, Stage B). For the latter (with 3 different designs), successful results were obtained, similar to Stage A, but not the improvements expected from the numerical simulation. Future activities are aimed in consolidating the new manufacturing processes.
Regarding the power management bay, the four heat sink temperatures have been kept within the required temperature constraints, while the measurements of airflow and velocity confirm an adequate flow+velocity distribution. Two bays equipped with four heat sinks have been constructed and delivered.

Arbeit, die ab Beginn des Projekts bis zum Ende des durch den Bericht erfassten Berichtszeitraums geleistet wurde, und die wichtigsten bis dahin erzielten Ergebnisse

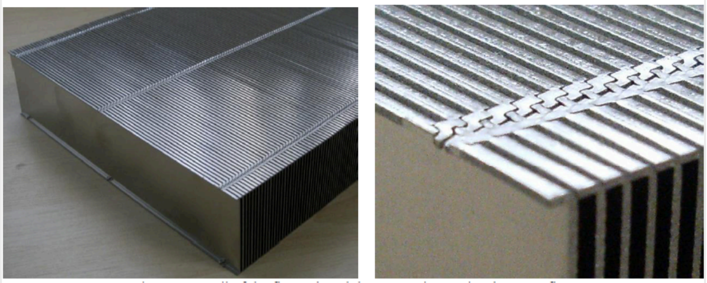
During the start project period, the work was focused on the predesign and design phases , which, supported by detailed state-of-the-art review, provided heat sink and bay designs that fulfilled the project requirements.
The subsequent design phase assured the optimum implementation of APG and MMCs into the heat sink, considering the manufacturing limits, refining aspects to obtain improved performances, etc.
Regarding Stage A, the Project has covered the design, manufacturing and testing (thermal, salt-fog, vibration) of the heat sinks. The results accomplished the requirements for temperature level, pressure drop and weight.

Regarding the integration of APG and MMC (Stage B), some coupon samples have been investigated, confirming the correct bonding between the materials, and reporting their equivalent conductivity.
In parallel, the Stage B design has also progressed, leading to three different options, manufactured and tested (thermal, salt-fog, vibration). The obtained results are satisfactory, with similar performance to Stage A.
In relation with the bay, the design has been progressively refined, from the PEM (box enclosing the heat sinks), the duct assembly managing the air flow towards the PEMs, and to the whole bay structure containing also other electric/electronic components. The tests on the duct assembly confirm an adequate flow and velocity uniformity at each heat sink channel. From the thermal side, the heat sinks integrated in the bay show very similar temperature levels compared to the corresponding stand-alone tests.
As a final overview of the results, the project has been able to design, manufacture and test successfully four different types of innovative heat sink. One of them incorporating APG , and the other three with different combinations of APG and MMC. The tests have confirmed the units can dissipate the expected heat with surface temperatures below the given threshold, keeping the air pressure drop and the weight within the limits. This result is very important as conclusive to confirm to the TM and Clean Sky that the innovation track of combining new high temperature electronics (SiC) with innovative high-tech material heat sinks is promising. Some improvements have also been identified after the first time manufacturing of the new heat sinks during the project, thus future activities will probably enhance the current performance and robustness levels.
The final implementation into the aircraft cannot rely only in an innovative and efficient air cooled heat sink; there is the need to provide adequate air flow distribution among different units into the power management bay. In this sense, the bay results confirm the pedigree of the design developed, as showing adequate flow/velocity distribution, and temperature levels.
The consortium has disseminated the results in an aircraft related Conference paper, summarizing the activities and results obtained. Another contribution to a Workshop in the Thermal Management field has reflected the developments of Stage A heat sinks, and also the analysis of new material coupon samples.
The partners have identified future possibilities of exploitation for the heat sinks (one with only integrating APG, and a second one integrating APG and MMC inserts) and new materials generated during the project (a new MMC material with high thermal conductivity anisotropy which opens the possibility to exploit it in heat spreader applications).

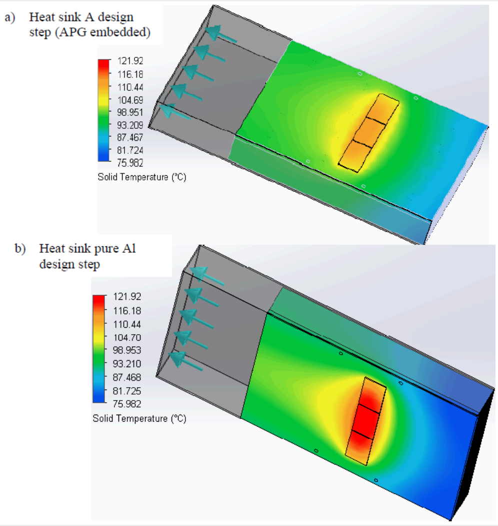
Fortschritte, die über den aktuellen Stand der Technik hinausgehen und voraussichtliche potenzielle Auswirkungen (einschließlich der bis dato erzielten sozioökonomischen Auswirkungen und weiter gefassten gesellschaftlichen Auswirkungen des Projekts)

Progress beyond the state of the art:
1-A heat sink integrating APG material has been manufactured and tested, showing results accomplishing the requirements. The incorporation of APG inserts in an air cooled finned heat sink is

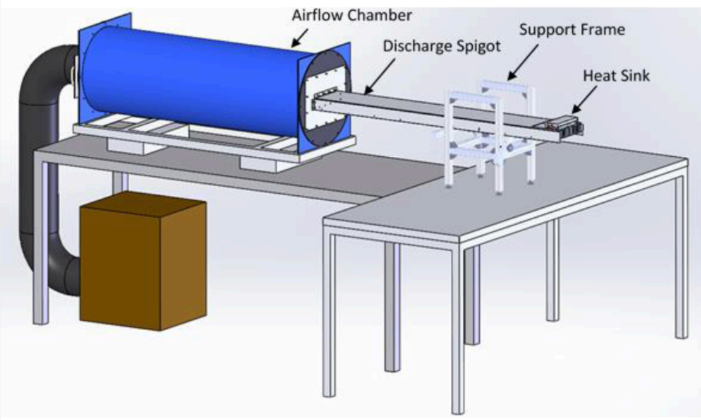
a totally new application, as they are typically implemented as heat spreaders between solid surfaces.
2-The APG sheets have been successfully encapsulated by MMC instead of aluminium, while APG + MMC have also been inserted simultaneously in another heat sink. These combinations are a strong innovation, as the first time incorporating the best of the two materials into a single product.
3-The feasibility of the implementation of the new heat sinks has been assured by the successful design of a power management bay that provides a good flow distribution for the different heat sinks. This is the core of a new lighter air-cooled power electronics management center, beyond the current state-of-the-art where the units are liquid or two phase cooled.
The global trends are clearly oriented to a renewable energy based world and to the electric mobility. In both, the energy conversion and the related thermal management are key aspects. Thus, the innovative track consolidated during ICOPE has a clear socio-economic impact, as the deployment of lighter and reliable air-cooled thermal management solutions.



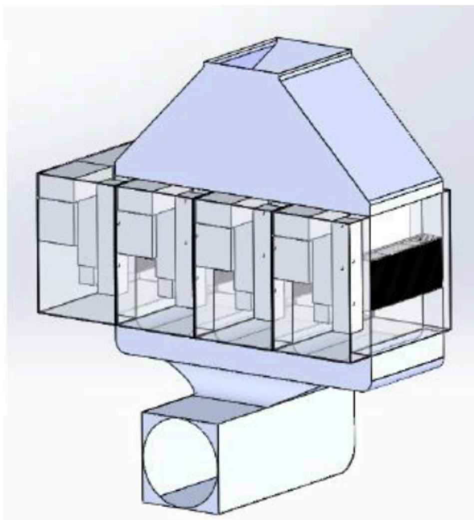
Stage A prototype: detail of the fin stack and the connections points between fins



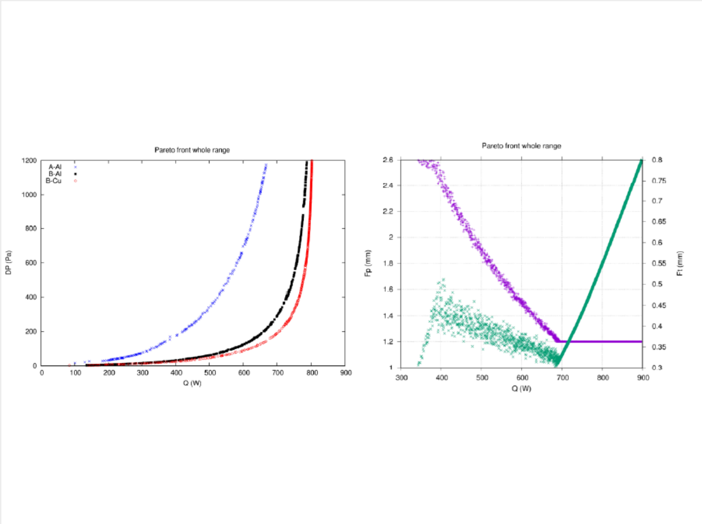
Heat sink A heat spreading improvement. Top: unit with APG insertions. Bottom: pure Al solution



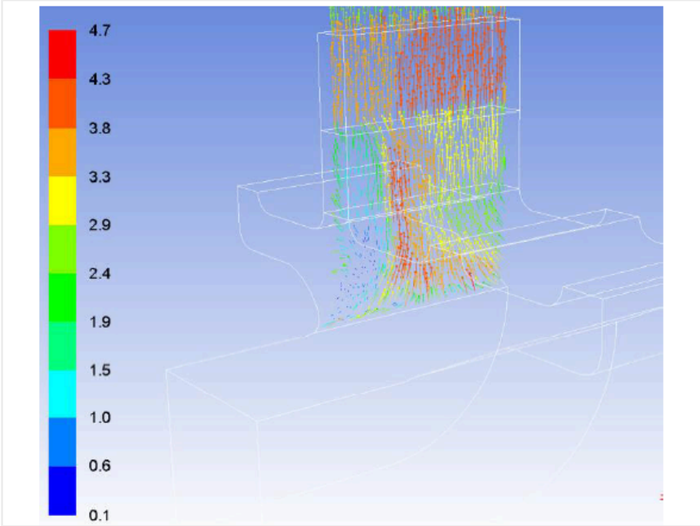
Heat Sink Test Bench Concept



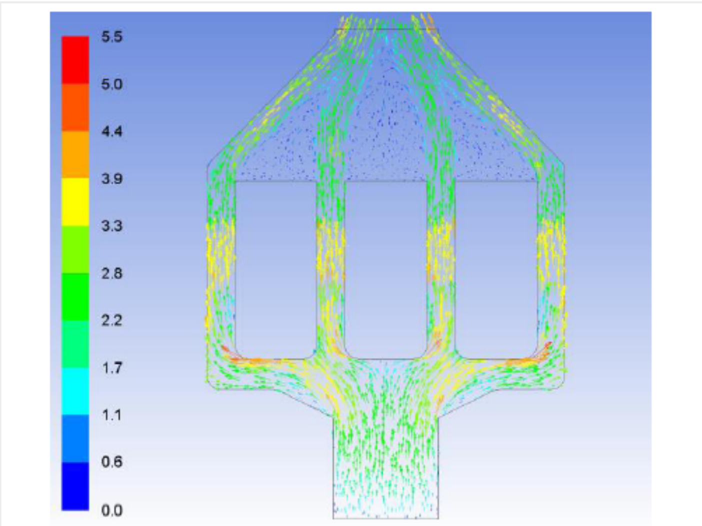
Ducting assembly that distributes the air flow among four PEMs. Preliminary design



Optimisation of the heat sink using genetic algorithms: obtained Pareto front and geometry.



Illustrative case showing velocity vectors after the inlet turn of the duct assembly.



Illustrative case velocity distribution between the four heat sinks within the duct assembly.

Letzte Aktualisierung: 3 September 2024

Permalink: https://cordis.europa.eu/project/id/755556/reporting/de