Fraunhofer ICT

Electromobility

Polymer composites for advanced electric drivetrain applications

Motivation and objectives

Electric drivetrains are regarded as a key element in sustainable and environmentally friendly mobility. For the simultaneous optimization of power-to-weight ratio, efficiency and costs, polymer composite materials offer attractive application potential. The high-performance electric motor concept designed and validated at Fraunhofer ICT (see figure 1) incorporates an internally cooled stator. The chosen cooling concept significantly increases the continuous power density of the motor compared to the state of the art.

An innovative battery module concept developed at Fraunhofer ICT (see figure 2) demonstrates the versatility of polymer composite materials in electromobility applications, especially focusing on controlling thermal runaway propagation.

Electric motor concept

The PerKuel motor concept is based on a hairpin stator overmolded with a highly thermally conductive epoxy molding compound. Cooling channels are integrated directly into the slot and yoke regions of the stator. This allows the winding losses to be dissipated close to where they are generated, while eliminating the need for a conventional external water jacket. In addition, the molding compound electrically insulates the hairpins from the stator core and offers the potential to replace conventional slot insulation.

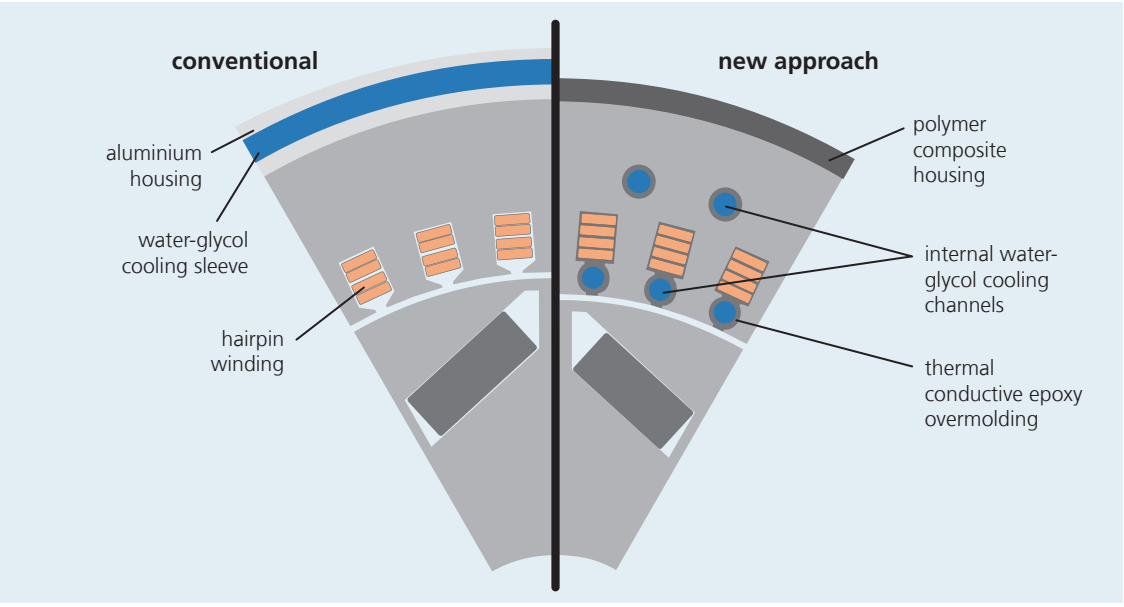
The concept was developed for a high-performance traction motor with a simulated continuous power output of approxi-mately 390 kW. Compared with conventional water-jacket cooling, the integrated cooling concept increases the continuous torque by approximately 40 % and the continuous power by 65 % within the same installation space and coolant conditions. The underlying concept of integrating cooling channels into polymer-overmolded stators can also be transferred to other power ranges and electric-drive applications.



1 High-performance composite electric motor design.



2 Battery module concept.



3 Comparison between conventional construction (left) and the new approach for electric motor cooling (right).

Battery module concept

Through the sophisticated use of polymer composite materials, Fraunhofer ICT has developed concepts that improve manufacturability, enable advanced tab-cooling systems, and increase protection against thermal runaway. These concepts can combine both continuous and discontinuous fiber reinforcements, with the materials tailored to the specific requirements of battery modules.

Continuous fibers, for example in a base-plate sandwich design, provide impact protection. By utilizing the design freedom offered by discontinuous fiber reinforcement, a high degree of functional integration, including load introduction and flame retardancy, can be achieved at a cost-competitive level.

Materials and manufacturing methods

With our broad experience in composite manufacturing processes, we use the right material in the right place by considering the structural, electrical and other functional requirements. For example, highly filled, thermally conductive molding compounds offer a strong potential to integrate functions such as cooling channels directly during manufacturing. Their low viscosity during mold filling means that copper windings, sensors and electrical connections are encapsulated without damage. To ensure the structural integrity of the electric motor concept, the overmolded stator assembly is mounted in an injection-molded housing made of a structural phenolic resin molding compound.

The selected thermosetting compounds have good mechanical properties even at high temperatures. They are also resistant to the coolants used and are characterized by high dimensional stability.

Our development approach

With our extensive design experience, we develop groundbreaking new applications together with our partners, both in publicly funded and in industrial projects. The entire product development chain, starting with CAD and CAE-supported design and simulation, prototype manufacturing and product validation, can be realized at Fraunhofer ICT.

Our development partners

- Karlsruhe Institute of Technology (KIT) – Institute of Electrical Engineering (ETI), Hybrid Electric Vehicles
- Karlsruhe Institute of Technology (KIT) – Institute of Vehicle System Technology (FAST), Lightweight Technology
- SciMo GmbH – Science for Motion

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