Fraunhofer ICT

Electromobility

Lightweight applications using polymer composite materials

Motivation and objectives

Electric drive trains 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 potentials. The high-performance electric motor concept designed and validated at Fraunhofer ICT (see figure 1) incorporates direct cooling of both the stator and the rotor. 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 versality of polymer composite materials in electromobility applications.

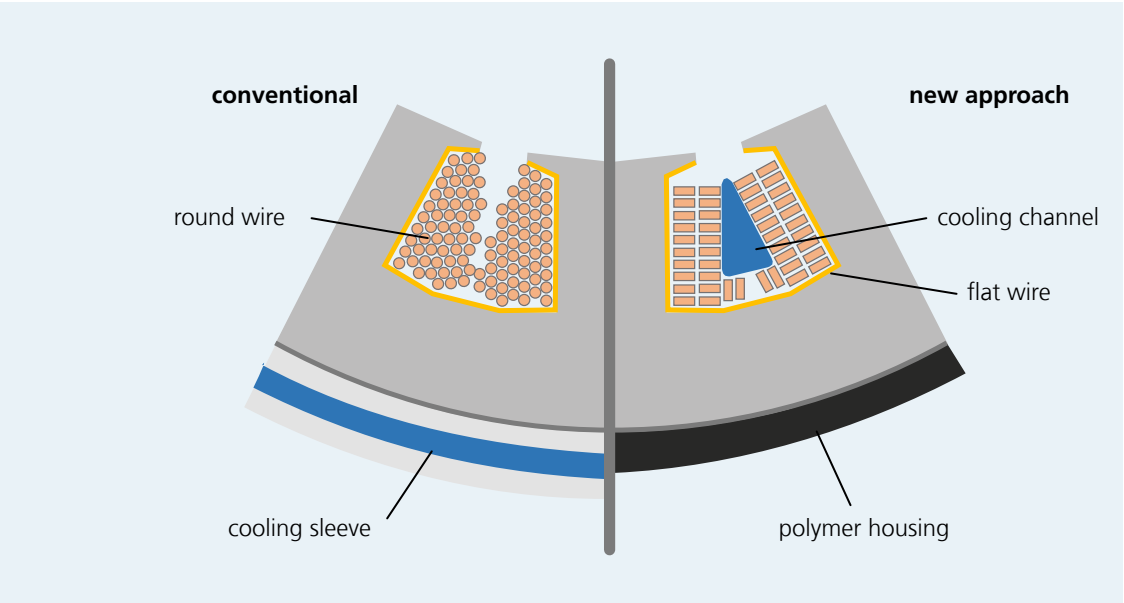
Electric motor concept

The core of the motor is a stator consisting of twelve segmented individual teeth, which are wound upright using a flat wire. The use of rectangular flat wires instead of conventional round wires leads to triangular spaces between two winding phases, which can be used as cooling channels (see figure 3). Due to the rectangular shape of the wire, the copper cross-sectional area remains unchanged. This means that the heat loss can be dissipated directly in the stator, close to where it is generated. The distribution of the cooling water flow to the individual cooling channels takes place in the bearing shields, in which ring-shaped channels arise as a result of the assembly. Through rotor cooling with a fixed water lance in the shaft, the heat from the rotor loss of the rotor can also be dissipated directly into the cooling water.

The functional demonstrator developed in this project has a continuous power output of 58 kW at a weight of 12 kg. It is designed for traction applications in electromobility. However, the basic concept of internal cooling channels in polymer materials can also be transferred to other power ranges and fields of application.

1 High-performance electric motor for traction applications.

2 Battery module concept.



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

Battery module concept

With a sophisticated use of polymer composite materials, the developed concept has improved manufacturability, an advanced cooling system and an increased protection against thermal runaway. By using both continuous and discontinuous reinforcement fibers, the materials are tailored to the specific requirements of each part of the battery module. Continuous fibers in the base plate sandwich construction offer impact protection. By using discontinuous fibers for the upper part of the enclosure, a high degree of functional integration (load introduction, flame retardancy) at a cost-competitive level is achieved.

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, which also contains the rotor bearing and the cooling circuit seals.

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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