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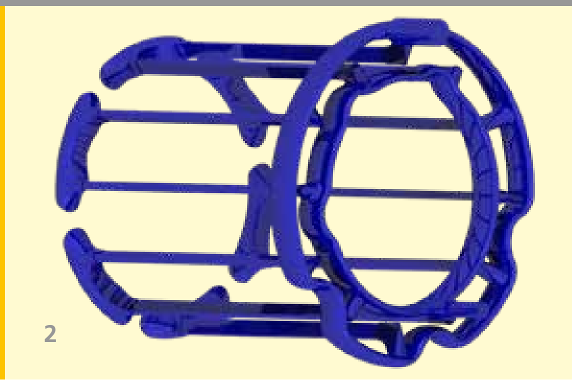

1 *Cross-sectional view of the electric motor.*
2 *Cooling water circuit in the stator*

# DIRECTLY COOLED ELECTRIC MOTOR FOR TRACTION APPLICATIONS USING POLYMER MATERIALS

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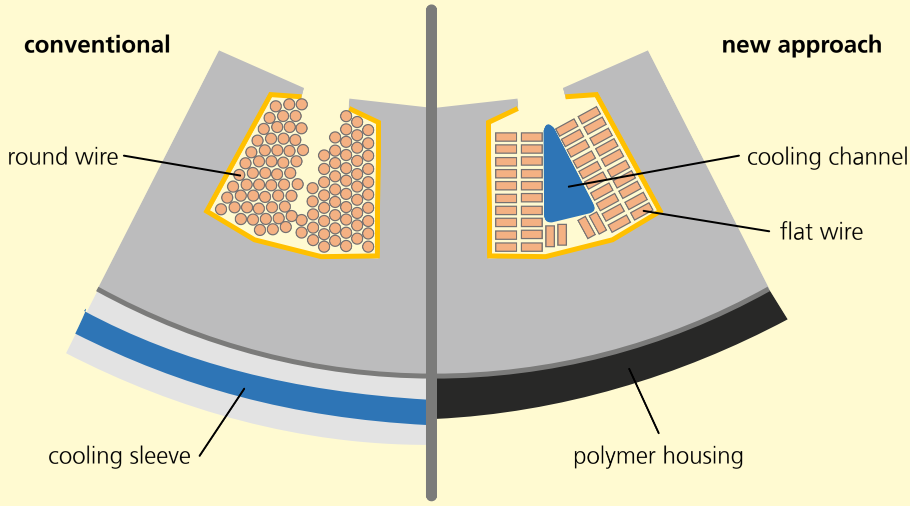
## Motivation and objectives

Electric drive trains are regarded as a key element in sustainable and environmentally friendly mobility. For the simultaneous optimization of power density, efficiency and costs, a new approach is presented for a permanent magnet synchronous machine. It is constructed from polymer materials and incorporates direct cooling of the stator and the rotor (1). The chosen cooling concept significantly increases the continuous power density of the motor compared to the state of the art. In addition, the new cooling concept enables the use of polymer materials, which have a low thermal conductivity compared to metals.

## Concept

The core of the motor is a stator consisting of twelve segmented individual teeth, which are wound upright using a flat wire. Using rectangular flat wires instead of conventional round wires leads to triangular spaces between two winding phases, which can be used as cooling channels (2, 3). Due to the rectangular shape of the wire, the copper cross-sectional area remains unchanged. This means that the heat lost 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 loss of the rotor can also be dissipated directly into the cooling water.

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The functional demonstrator developed in this project, with its expected continuous output of 50kW, is designed for traction applications in electric mobility. However, the basic concept of internal cooling channels in polymer materials can also be transferred to other power ranges and fields of application.

## Material and manufacturing methods

All electrically active parts of the stator assembly are overmolded with a highly filled, thermally conductive epoxy resin molding compound (Sumikon EME-A730E) in a transfer molding process, with the cooling channels being formed by mold cores. The low viscosity during mold filling means that copper windings, sensors and electrical connections are encapsulated without damage. To ensure the structural integrity of the motor, the overmolded stator assembly is mounted in an injection-molded housing made of a structural phenolic resin molding compound (Vyncolit X7700), 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.

## Project partners

- Fraunhofer Institute for Chemical Technology ICT – New Drive Systems and Polymer Engineering Departments
- 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

## Acknowledgements

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**3** *Comparison between conventional construction (left) and the new approach (right)*