First steps toward high-speed motors for fuel cell components

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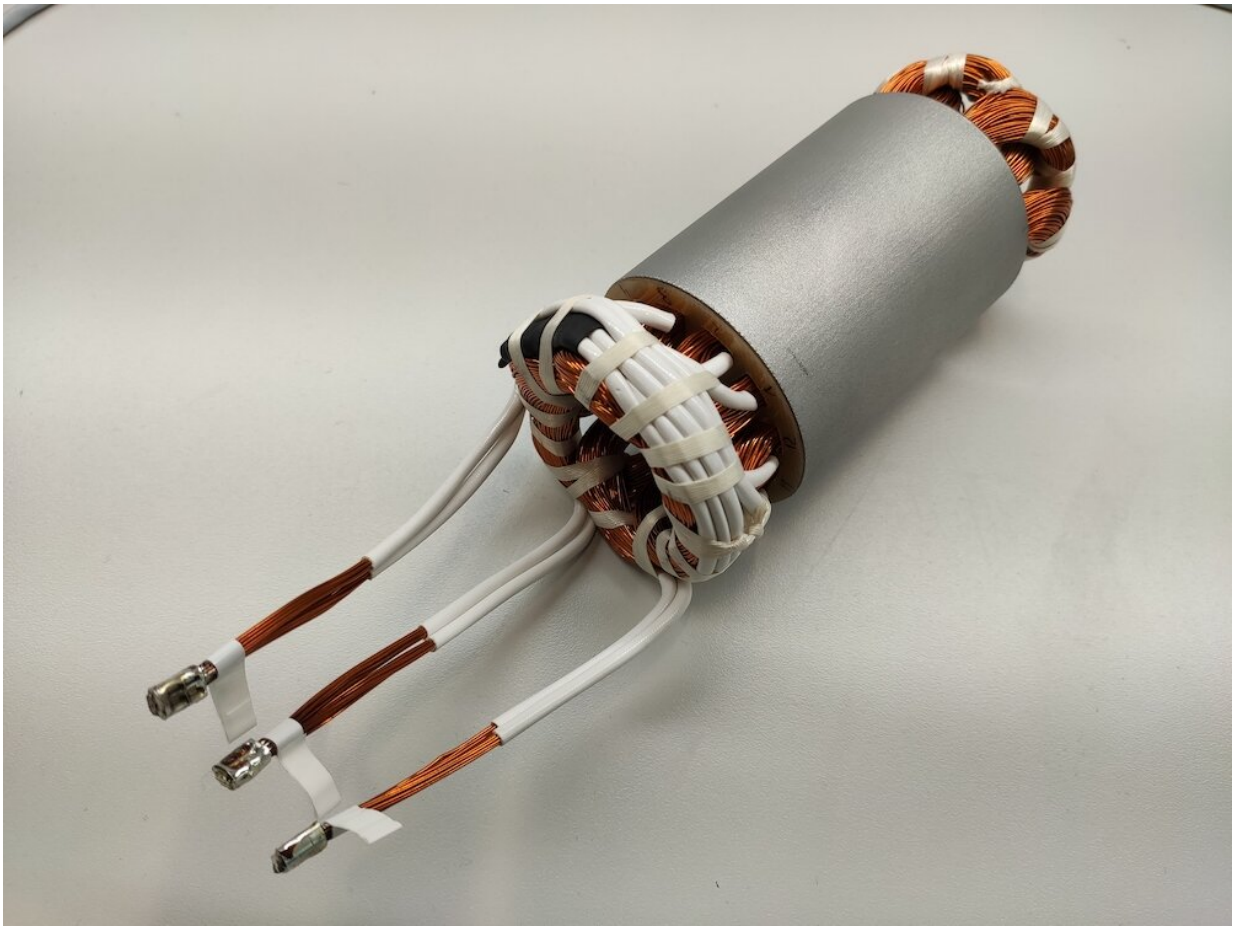

Prototype of a high-speed motor for a fuel cell compressor. Credit: Fraunhofer project HABICHT

The transport sector is transforming towards climate-friendly powertrains with significantly reduced CO_2 emissions. The electrification of powertrains remains a major challenge not only for trucks, buses, trains, and ships but also for aircraft. These applications cannot be realized in the future with batteries because of the energy requirements. The fuel cell is an extremely promising energy supplier for these applications, which supplies electrical energy from stored hydrogen and ambient air.

Fraunhofer Institutes LBF, IFAM, IISB, and SCAI joined their forces to develop advanced and highly efficient components for fuel cells. The project HABICHT aims to design and develop a high-speed motor for a fuel cell compressor to enable innovation in the utility vehicle and aviation domain. The electric machine should at least achieve a power density of 30 kW/kg by using innovative materials for direct cooling of the stator and maximizing the rotor's high-speed capability (

Current status: First design based on analytical and numerical calculations

Based on the rapid definition of the specifications, a viable concept for electromagnetic design has been developed with analytical and numerical support. The work was carried out in interaction with structural-mechanical investigations on the speed stability of the permanent magnets as well as with thermal investigations on the necessary cooling capacity, which is guaranteed by the combination of cooling jacket, hollow rotor shaft, and thermal connection of the winding head with a dielectric fluid. Within HABICHT, Fraunhofer SCAI is responsible for multi-physics modeling and the setup of a smart design environment for electrical engines.

Future work: Optimization and benchmarking

The future work is focused on optimization of the current working design and execution in a manner suitable for production. For this purpose, reduced test carriers are to be used for stator winding, electrical insulation, banding, sheet metal cutting, bonding, and magnet shaping, among other things, prior to the construction of the entire system. The forming of cooling channels formed during potting is to be solved in terms of process and material technology based on the literature studies already carried out. The adaptation of the HABICHT machine to an existing turbo compressor is to be realized with suitable but at the same time conventional shaft and bearing technology, whereby the frequency-dependent inherent dynamics of the mechanical moving parts are to be determined in advance.

The HABICHT project is supported by external advisors from aviation, e-mobility, suppliers, and academia. Prof. Dr.-Ing. Jürgen Ulm from Heilbronn University of Applied Sciences sees excellent potential in the project results for future requirements and applications from the industry:

"The project involves the development of new technologies in the field of high-speed electric drives in the application for fuel cells and sets new standards, which in turn point the way for future developments. The high-speed rotor, which poses a challenge in terms of its mechanical, thermal and electromagnetic design, is of great importance here. This project is an excellent example of pioneering high-tech product development in conjunction with simultaneous materials and measurement development and simulation technology."

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