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M1Or3G-06: [Invited] New concept for cryogenic gaseous hydrogen-cooled lightweight electric engine

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Electric propulsion is one way of making low emission flying possible. To do so, they must be particularly lightweight and have a high efficiency, at least as good as current systems such as gas turbines or turboprop engines. In order to reduce the impact of global transport on the environment and pollutant emissions, a revision of current systems is necessary and expedient. Because of its high energy density, cryogenic liquid hydrogen can be used in combination with fuel cells both as an efficient supplier of energy and for effective cooling of the electric motor. The development of this system concept is the subject of the "AdHyBau" research project, of which the authors are part of the consortium. The basic system architecture of the hybrid electric powertrain was presented by partners here [1]. A DAHER TBM850 was used as a reference. This application scenario results in extremely different temperatures in different areas of the electric motor at different operating points. In addition, electrical contact and the flow of gaseous hydrogen pose special challenges. Not to be forgotten are the mechanical demands on the motor in terms of power, torque and speed.
This paper presents the engineering design process and the resulting concept for such an electric engine. After the development of the concept for the rotor was presented here [2], the development of the concept for the stator is discussed here.
The development of the concept for the rotor has been presented here [2]. Based on the requirement classes mentioned in [1], the concrete requirements resulting from flight operation and the approach of cooling with cryogenic gaseous hydrogen are first compiled. Then, the selected electrical concept of a 500 kW engine is presented, which serves as a basis for identifying the required components and their arrangement. Compared to conventional electric motors, additional components are required. These include hollow coils, structures to distribute the cold gaseous hydrogen to the coils and elements to support the stator laminations with the coils. Materials are then selected for these components with the aim of minimizing weight, and their geometries are predimensioned using analytical approaches and numerical methods. Finally, the individual concepts are synthesized into an overall concept.
The result is a compact design for a cryogenically cooled electric motor with a power density of more than 10 kW/kg and a mass of less than 50 kg.

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Literature

[1] Vietze M, Weiland S, System analysis and requirements derivation of a hydrogen-electric aircraft powertrain, International Journal of Hydrogen Energy, https://doi.org/10.1016/j.ijhydene.2022.09.052
[2] M. Pohl et al 2022 IOP Conf. Ser.: Mater. Sci. Eng. 1226 012077, https://doi.org/10.1088/1757-899X/1226/1/012077

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