Development of a 2 MW REBCO Fully Superconducting Synchronous Generator

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Abstract

Achieving carbon-neutral growth in the aviation sector requires innovative propulsion technologies, among which electric propulsion systems represent a promising solution. To realize such systems, lightweight motors and generators are essential. Superconducting machines can achieve higher power density than conventional machines because superconducting wires generate strong magnetic fields without the need for an iron core. In a previous project, we successfully fabricated and tested a 400-kW-class fully superconducting synchronous machine using REBCO tapes [1], [2]. Building on this achievement, we have launched a new project supported by the New Energy and Industrial Development Organization to design and develop a 2-MW electric propulsion system consisting of a motor, cable, and generator. This paper reports the design and key features of the 2-MW fully superconducting synchronous generator. The generator is designed as a two-pole machine operating at 3,600 rpm. To ensure mechanical integrity at high rotational speeds, a high-stiffness through-shaft was implemented, and saddle-shaped windings were adopted for the field coil. The armature employs a novel distributed winding scheme in which the U, V, and W phases overlap by 60º through variation in winding radius. Each winding consists of 20 stacked face-to-face double-stacked (FFDS) REBCO tapes, with reversed tape positions between adjacent turns to ensure uniform current distribution. A prototype field coil was fabricated and tested in liquid nitrogen to evaluate the feasibility of the winding process. The coil was wound on a glass fiber-reinforced plastic (GFRP) bobbin with a diameter of 300 mm and a length of 800 mm. During winding, 4 mm wide and 0.26 mm thick FFDS tapes with polyimide insulation were connected, forming a total tape length of 1.6 km. Voltage-current characteristics measured in liquid nitrogen showed a critical current of above 80 A and an n-value of 24, confirming that no damage occurred. This presentation highlights the electromagnetic design and experimental results of the prototype field and armature coils.

References

1)H. Miyazaki et al. IEEE Trans. Appl. Supercond., vol 34, no. 5, pp. 1-6, 2024, Art no. 5200506.
2)H. Miyazaki et al. IEEE Trans. Appl. Supercond., vol 35, no. 5, pp. 1-5, 2025, Art no. 5201305.

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