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M2Or4A-02: [Invited] Current Status of Development of Fully Superconducting Propulsion Systems for Aircrafts in Japan

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In Japan, the development of fully superconducting propulsion systems for aircrafts have been conducted as a NEDO project. The target is a 20 MW propulsion system for an aircraft with 100-200 passengers. It is planned to be composed of 2 10-MW fully superconducting generators, 10 2-MW fully superconducting motors, superconducting cables, inverters which operate at liquid nitrogen (LN2) temperature, 2 hydrogen gas turbines and so on. Superconducting generators, motors, cables and inverters are cooled by subcooled LN2 at 65 to 77 K. The fuel is liquid hydrogen (LH2). LN2 is cooled through heat exchange between LH2 and LN2. The first phase of NEDO project for 5 years ended in March 2024. Here a 400 kW fully superconducting synchronous machine was designed and manufactured by way of trial. It can operate as a synchronous motor and a generator. The rotating field winding and armature winding were made of YBa2C3O7-d coated conductors. The field winding was wound of a single REBCO tape. The armature winding was wound of stacked six REBCO tapes with adequate transpositions during the winding process. The casing of the fully superconducting synchronous machine was made of CFRP, which contributed to less eddy current loss. The rotor was cooled by helium gas at around 60 to 70 K. The armature winding was cooled by forced-flowed subcooled LN2. As a motor test, it was operated up to 460 rpm by using three bipolar power supplies. And, as a generator test, it was operated up to 2500 rpm as a rated rotation speed by using a conventional synchronous motor. The output power of 250 kW was confirmed. In addition, a lightweight superconducting cable, which had corrugate tubes of resin as an inner and outer walls of vacuum thermal insulation layer, was developed. It was flexible even at LN2 temperature. The second phase of NEDO project started in June 2024. It will continue for three years. We will develop a 1-2 MW fully superconducting synchronous machine using REBCO tapes. As the armature winding, a distributed-type winding, which was developed in the previous phase of NEDO project, will be adopted instead of a concentrated-type winding. And a mechanical seal which was developed using a surface texture technology will be adopted instead of a magnetic fluid seal which was used as a seal system around the rotating axis in the previous phase of NEDO project. In this conference, we will report the test results of the 400 kW fully superconducting synchronous machine and introduce the development plan of a 1-2 MW fully superconducting machine in the present NEDO project.

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