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[Invited] Development of Superconducting PM Machines

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High-temperature superconducting (HTS) materials offer a mature core-technology for propulsion motor/generators in transportation. In Japan, 1-3 MW synchronous motors for ship propulsion have been developed by industry-national institute-academia liaison using HTS wires. As alternative choice for field poles, melt-growth bulk HTS provides a successful design and making of prototype modules for 10-30 kW rotating machines. An effective magnetization for the HTS bulks is a key to achieving a high magnetic flux density, which provides a superior field pole compared with conventional machines. For practical applications, the pulsed field magnetization (PFM) after cooling below Tc continues to be developed to attain a compact fixture. Employing several milliseconds rise time and a duration of four seconds with a waveform control made by active feedback of the Hall sensor voltage as a function of time, the HTS bulk traps a high magnetic flux density that exceeds 90 % of that obtained by conventional and slow field cooled magnetization. In a rotating machine application, the design of the armature/magnetization coil must meet the requirements of the field-pole bulks and be compact and light weight. In contrast to HTS tape-wound coils, using either 1G and/or 2G wires, active control of the magnetic flux generated by dc pulsed current control can be accomplished by applying complementary magnetization or demagnetization. Research also continues on the magnetic flux dynamics towards an optimum set of PFM parameters. A Neon thermosyphon cooling has been applied to enhance and control useful field pole strength. In large output power applications, such as wind/ocean renewable energy generators and ship/aeronautic propulsion motors, these machines are highly desirable because of their potential for high energy density per weight/volume. In this paper, we review the current status, and the worldwide progress with the development of superconducting PM machines.

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