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A Superconducting Vernier Motor for Electric Ship Propulsion

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Due to the high efficiency, high power density and high flexibility for maneuvering and docking, electric propulsion systems for marine propulsion attract more and more attention in recent year. Generally, the motor for marine propulsion operates at a low speed which implies that the size of the motor tends to be large. By eliminating the transmission gear, the vernier permanent-magnet (PM) machine is very suitable for low-speed high-torque direct-drive applications. However, for those power levels beyond Mega Watts, the costs for PM machines are high and the PM is also subject to demagnetization due to overheat and mechanical vibrations. Based on these concerns, the superconducting motors are invented for the marine propulsion applications. In this paper, a new vernier machine (VM) is proposed which incorporates high temperature superconducting (HTS) field windings for the field excitation. Therefore, the power density of the proposed machine can greatly be improved and meanwhile avoiding the irreversible demagnetization of PMs. The proposed HTS-VM for electric ships adopts an inner-stator and outer-rotor configuration. The stator adopts the split-pole structure. Both the armature and the HTS field excitation windings are housed on the stator, therefore the structure of the stationary parts can be significantly simplified and the reliability is hence improved. Correspondingly, the rotor consists of iron lamination only. By using the iron core, the consumption of HTS wires will be reduced. The finite element method will be used for field calculation and machine analysis. Since the DC current in the HTS coils can be flexibly controlled, the starting torque can be enhanced and the constant power speed range can also be extended. Detailed design, analysis and evaluation will be presented in the full paper.
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