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M3Or2A-01 [Invited]: Study of Thermosyphon Cooling System for High-temperature Superconducting Machinery

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High-temperature superconductors (HTS) draw much interest in the shipbuilding and other transport industries as the urge to get high-power density and efficient electric propulsion systems. To achieve optimal performance of HTS field pole magnets in motors and generators, it is crucial to regulating the cooling temperature under 40 K and a simple and reliable cooling system is desired. A thermosyphon (TS) is a candidate since the operation principle consists in using natural convection without the intervention of mechanical circular pump. The system composition is simple and light-weight. The TS benefits from a high heat transfer coefficient thanks to latent heat. The available temperature for TS depends on the saturation temperature of the refrigerant, which provides adequate controllable cooling for cryogenic machine application. Using neon enables us to supply cooling temperatures of 28-40 K range. To determine the optimal gas-liquid state operation for HTS motors, a scaled model of a TS cooling system for large scale ship propulsion motor was studied. This enabled us to visualize any phenomena and transient state change inside the evaporator part of the rotor by a viewport. We studied heat transfer capacity under heat load for different neon quantities. Neon heat flux was then calculated to determine the heat transfer area for effective cooling. The boiling curve leads to the refined evaporator design with optimal heat transfer area. In addition, we report a possible sustainable liquid-gas circulation without interruption under inclined condition required for the operation. The cryo-rotary joint is another key technical issue to be discussed. The present results contribute to the next stage HTS ship/aero transport and superconducting machine systems design.

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