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Electromagnetic Design and Performance Analysis of a Hybrid-Type Superconducting Fault Current Limiter in Shipboard MVDC IPS

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As medium voltage dc-based (MVDC) technology is widely considered in the shipboard integrated power system (IPS), the short fault protection of shipboard IPS is urgent. Superconducting fault current limiter (SFCL) is an efficient way to solve the short fault problems in shipboard MVDC IPS. A hybrid type SFCL (H-SFCL) based on a non-quenching inductor and two resistors have been developed in this study. The H-SFCL can limit the first peak value and the steady-state short-circuit, with no quenching and little heating. In this study, the short fault mechanism and mathematical model of the MVDC IPS DC pole-to-pole short circuit is analyzed. The current limiting indexes are proposed according to the existing situation of circuit breakers and short fault, and the current limiting performance of H-SFCL is verified. The scheme of annular structure parallel inductors is proposed to balance the current distribution and eliminate circulating current. The electromagnetic design of a 10 kV/6 kA H-SFCL prototype is completed based on a genetic algorithm, along with the performances of current-limiting capacity, response time, and loss of the prototype. The current distribution characteristics and electromagnetic optimization design are analyzed. The simulation results show that the H-SFCL prototype with electromagnetic parameters meets the design requirements and has superior performance in current reduction and loss.

Index Terms—Hybrid-type SFCL, electromagnetic design, fault current limiting, shipboard MVDC IPS.

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