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Wed-Af-Po.04-06: Design and Fabrication of Current Leads for Superconducting Rotor Cooled with Rotating Cryocooler

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The concept of a rotating cryocooler for superconducting rotating machines eliminates the need for cryogenic liquids in the cooling loop, thereby simplifying and compacting the cooling system. This approach enables the development of extremely lightweight machines with high torque density. However, at high rotational speeds (e.g., >3000 rpm), operational conditions often limit the applicability of off-the-shelf cryocoolers for rotational use. As a result, the cooling power of a rotating cryocooler may be constrained and must be carefully considered in the overall cooling system design, including provisions for current leads, radiation shields, and other thermal management components. In this study, we present the design and fabrication of current leads for a superconducting rotor cooled with a rotating cryocooler. The cryocooler utilized is a single-stage Stirling cryocooler with a symmetric structure, centrally positioned within the motor and rotating along its axis. The designed current leads are divided into two sections: (1) the connection from the feed-throughs to the cold tip of the cryocooler and (2) the connection from the cold tip to the rotor. The first section employs a non-superconducting conductor optimized to minimize the total heat load, accounting for both heat intrusion and heat generation. The second section utilizes a copper bus bar reinforced with superconducting tapes to ensure low-loss current transfer. Prototype fabrication results are provided, along with performance test data, demonstrating the feasibility, efficiency, and practicality of the proposed current lead design.

Author: BONG, Uijong (Hinetics, Inc.)

Co-authors: BALACHANDRAN, Thanatheepan (HInetics Inc); Dr SIRIMANNA, Samith (Hinetics, Inc.); XIAO, Jianqiao (Hinetics Inc); Dr SALK, Noah (Hinetics, Inc.); Mr VENKATARAMAN, Raatan (Hinetics, Inc.); HARAN, Kiruba (University of Illinois)

Presenter: BONG, Uijong (Hinetics, Inc.)

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