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C2Po2C-02 [08]: Thermal Optimization in Design of Functional Insertion Components for Cryogenic Applications

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Various functional insertion components (FIC), directly connecting a cold mass and the ambient environment, are irreplaceable and play crucial technical roles in many superconducting cryogenic applications. However, such components also bring a huge heat leak to the cold mass within the cryostat. The heat leak is usually much greater than that through entire evacuated MLI insulation system and solid support structures combined. Therefore, this situation brings unimaginable challenges not only to the refrigeration loads to be met but also critical aspects of the FIC design in satisfaction of highly restrictive, even contradicting technical functions. The FIC must simultaneously minimize the heat leak provide a large amounts of DC current and RF power to/from the cold mass, as well as provide a reliable ultrahigh vacuum thermal isolation break with strong mechanical stability. Reviewed are the following commonly used FICs: 1) various RF input couplers for transmitting MW-RF power; 2) high DC power current leads for energizing various SC magnets; 3) various high order mode (HOM) couplers for damping unwanted RF energy; 4) instrumentation cable/wire to cold mass; and 5) functional interconnection pipes between cold mass and cryostat. Discussions with tables, charts and figures in the paper will mainly be focused on the methodology of thermal analyses, structure design, choices of materials, and coating/treatment of surfaces facing RF fields. Accomplishments of the cooling techniques for FICs are briefly reviewed including forced flow cryogen cooling, returning cold vapors, and thermal anchors to intermediate temperatures.
Approaches to efficiently minimize the DC current heating, RF surface heating, and heat leak through the solid body of FIC, while reliably providing the technical functions, are systematically discusseded, summarized and compared for select applications from around the world.

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