A Frictionless Sliding Mechanism for Reciprocating Magnetic Refrigeration Systems using Flux-Pinned Bulk HTSs

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Abstract

The magnetocaloric effect is realized by varying the magnetic field applied to a magnetocaloric material (MCM). Magnetic refrigeration systems, which exploit this effect, are expected to be applied not only to hydrogen liquefiers but also to a wide range of cooling technologies. In the reciprocating-type magnetic refrigeration demonstrator, the variation of the magnetic field was achieved by changing the distance between the magnetic field source and the MCM(1. A schematic illustration of this concept is shown in Figure 1. The superconducting magnet was fixed in place, while the MCM was driven axially by an actuator. As the MCM approaches the superconducting magnet, an attractive magnetic force acts between them. Under these conditions, one of the issues is how to support the radial magnetic force. According to previous studies, small-scale experimental devices designed as precursors to a scale-up demonstrator have been reported to experience radial magnetic forces as large as 1 kN(2. Without adequate support for the forces, this not only generates frictional heating in the cryostat but also causes wear of the contact components. When contact components are placed inside a cryostat, the use of lubricants becomes impractical due to the extremely low temperatures.

To address these issues, we conceived a levitation mechanism based on flux pinning in bulk High-Temperature Superconductors (HTSs). This mechanism is illustrated in Figure 2. Some readers may be familiar with demonstrations in which a bulk HTS slides smoothly above a rail of permanent magnets. In a similar manner, since it can move freely along the longitudinal direction of the guide without resistance, the motion driven by the actuator is not hindered. This "sliding system" should be designed to share the cryogenic environment of the superconducting magnet. By dispensing with frictional contacts, which are employed in reciprocating-type magnetic refrigeration systems, a completely frictionless driving mechanism is realized.

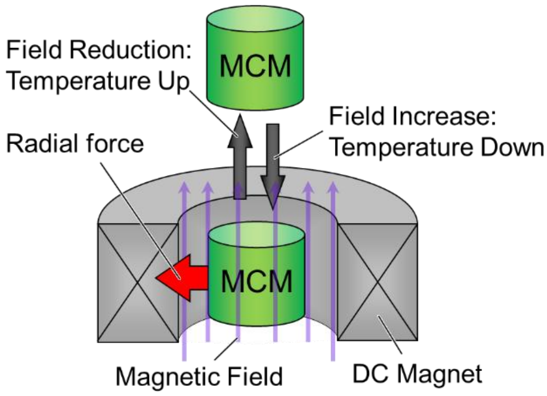

Figure 1 Reciprocating-type Magnetic Refrigeration system and radial magnetic force

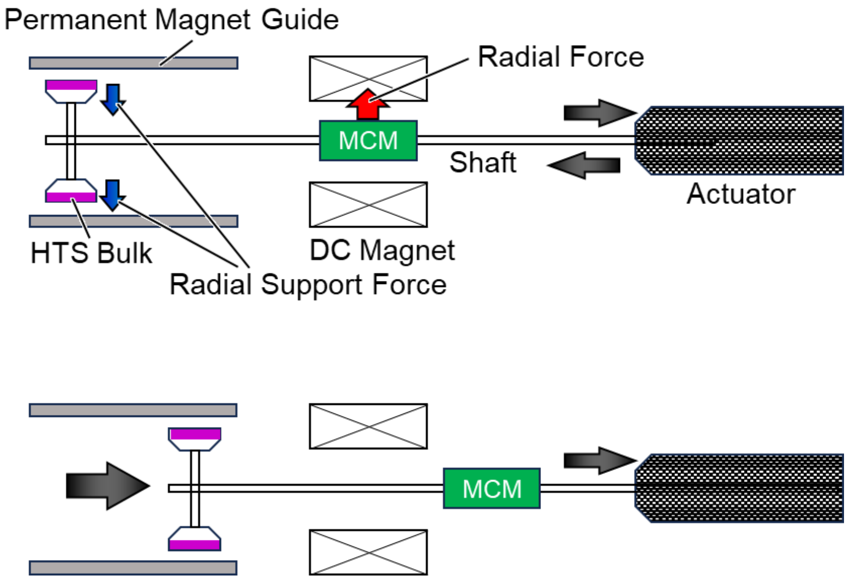

Figure 2 Levitation Mechanism based on Flux Pinning in Bulk HTSs for Reciprocating-type Magnetic Refrigeration System

References

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