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Gas gap heat switch for a Cryogen-free magnet system

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Cryogen-free superconducting magnet systems (CFMS) have become popular over the last two decades for the simple reason that the use of liquid helium is rather cumbersome and that helium is a scarce resource. Some available CFMS use a mechanical cryocooler as the magnet's cold source. However, the variable temperature inserts (VTI), for any CFMS, are not cryogen-free as they are still based on helium gas circulation through the sample space.

We designed a prototype of a gas gap heat switch (GGHS) that allows a thermal management of a completely cryogen-free magnet system, with no helium losses. The idea relies on a parallel cooling path to a variable temperature insert (VTI) of a magnetic properties measurement system under development at Inter-University Accelerator Centre. A Gifford-McMahon cryocooler (1.5 W @ 4.2 K) would serve primarily as the cold source of the superconducting magnet, dedicating 1 W to this cooling, under quite conservative safety factors. The remaining cooling power (0.5 W) is to be diverted towards a VTI through a controlled GGHS that was designed and built with a 100 μm gap length.

The built GGHS thermal performance was measured at 4 K, using helium as the exchange gas, and its conductance is compared both with a previously developed analytical model and a finite element analysis. Lessons learned lead to a new and more functional prototype yet to be reported. Modifications include an improved assembly and an upgraded cryopump actuator.

In order to achieve the optimization of the diverted heat flux we suggest using a temperature-controlled sorption pump to manage the pressure inside the GGHS, consequently varying the conductance all the way from the OFF to the ON state.

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