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Application of neon pulsating heat pipes to cryocooler-based HTS magnets

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Cryocoolers are increasingly favored over baths or forced-flow cooling providing heat removal and thermal stability for magnets made of High Temperature Superconductor (HTS). Efficient heat transfer between magnet and cryocooler is crucial to the operation of such a system. Compared to conventional thermal buses, which are typically made of solid materials such as high-purity copper braids, the Pulsating Heat Pipe (PHP) -a passive device that operates through thermally induced two-phase flow- offers superior heat transfer performance at a reduced mass. PHPs are commonly constructed from a capillary sized tube bent in serpentine between an evaporator (in contact with the coil) and a condenser (in contact with the cryocooler). This configuration minimizes the bulk while allowing large areas of the magnet to be cooled. The tube is filled with a cryogenic fluid at saturation conditions. Heat is efficiently transferred by a combination of latent and sensible heat transfer mechanisms. In addition to being efficient, lightweight, and passive, it functions as an autonomous thermal bus and switch, capable to operate in zero-gravity, high-magnetic-field and high-radiation environments. For these reasons, the Paul Scherrer Institute (PSI), in collaboration with the VDL Enabling Technologies Group (VDL ETG), has launched a project to design, manufacture, characterize, and apply cryogenic PHPs for enhancing the cooling efficiency and reliability of cryocooler-based HTS magnets.
This contribution presents an overview of the project. The dedicated test stand, designed and commissioned at PSI, is first described. The experimental results of the manufactured and characterized PHPs using neon as working fluid are then analyzed and discussed, leading to the definition of optimal parameters and correlations to predict their performances. The numerical model, currently under development to improve performance predictions, is also presented. Finally, the first applications, to our knowledge, of neon PHPs to cool and operate insulated and non-insulated HTS coils are described, and results of experimental campaigns are presented, leading to a proof of concept.

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