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Recent Progress in Pulsating Heat Pipe Technology for Cryogenic and Superconducting Systems

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ABSTRACT:

Pulsating heat pipe (PHP) technology has been developing rapidly for room temperature applications since its introduction in the early 1990s, however it is only recently being explored as an effective, passive mechanism for transferring heat at cryogenic temperatures. The advantages of the pulsating heat pipe include the absence of the wicking component that is essential for conventional heat pipes, and the resultant simplicity of fabrication as well as low weight, the possibility for orientation independent performance, and thermal conductance values an order of magnitude (or more) larger than those afforded by high conductivity metals. Measured values of an effective thermal conductivity exceeding 50,000 W/m-K in the liquid nitrogen and liquid hydrogen range, and 2400 W/m-K in the liquid helium range have generated an enthusiastic investigation into the use of PHPs to effectively spread cooling in cryogenic and superconducting systems. It will be of significant interest, for example, to explore how well the cooling supplied at the cold finger of a cryocooler can be spread throughout the windings of superconducting NMR or accelerator magnets. A myriad of physical properties influence the operation of the PHP and comprehensive models are still lacking that can successfully predict their thermal behavior. An overview of the present understanding regarding PHP behavior will be presented, along with results describing cryogenic PHPs using helium, hydrogen, neon, and nitrogen. Recent experimental and modeling activities at UW-Madison and Zhejiang University using helium, hydrogen, and nitrogen based PHPs will be highlighted.

BIOGRAPHY:

Professor John M. Pfotenhauer received his BA in physics from St. Olaf College in 1979, and his MA and PhD in physics from the University of Oregon in 1981 and 1984 respectively. In1984 he joined the Applied Superconductivity Center at the University of Wisconsin – Madison where he directed experiments related to the stability of He II cooled superconductors, the design of HTS current leads, and development of innovative cryocoolers - primarily with the Joule-Thomson and pulse tube refrigeration cycles. Professor Pfotenhauer's research has generated more than 100 publications. In August of 1993, he joined the faculty at the University of Wisconsin – Madison with a joint appointment in the Department of Mechanical Engineering and the Department of Engineering Physics. In addition to his research in cryogenics, and in educational games, he regularly teaches courses in thermodynamics, heat transfer, energy systems laboratory, cryogenics, and vacuum technology. Since 2006 he has also frequently visited Zhejiang University in Hangzhou, China, teaching similar topics and directing graduate student research in cryogenics. Professor Pfotenhauer has served on the Cryogenic Engineering Conference board since 1999, and contributes regularly to the Cryogenic Society of America through short courses and occasional articles in their trade journal "Cold Facts."