Opportunities and Challenges for Cooling HTS Power Applications with Gaseous Helium Circulation

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Most high temperature superconducting (HTS) power system components that have been demonstrated used liquid nitrogen (LN2) as the cryogen. Gaseous helium (GHe) is being explored as an option for cooling HTS power devices for specialized applications. A major advantage of using GHe is the versatility of operating temperature of HTS systems leading to significantly higher power densities compared to LN2 temperature regime. In some naval and aviation applications the broader operating temperature window allows the necessary flexibility in designing superconducting systems to tackle the gravimetric and volumetric power density design requirements. However, challenges do exist in using GHe as the cryogen due its weaker dielectric strength and lower thermal capacity compared to those of liquid nitrogen. This paper presents the research and development efforts at the Florida State University Center for Advanced Power Systems in Gaseous helium cooled HTS devices. The developments include GHe circulation systems with large mass flow rates, AC loss measurements at 20-80 K range, cryogenic dielectric characterization of GHe and HTS components in GHe, and novel designs for gaseous helium cooled power devices. The paper discusses examples of successful demonstrations of HTS devices cooled with gaseous helium and the implemented solutions for the challenges faced.

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