Modeling of Integrated Cryocooling Systems to Improve Resiliency of Superconducting Power Grids on Electric Transport Systems

R.D Machorro Swain, C.H Kim, P. Cheetham, and S. Pamidi, Florida State Univ. Center for Adv. Power Systems, FL

With the increasing demand for large all-electric transportation systems, resiliency and sustainability of cryogenic circulation systems is needed to facilitate high temperature superconducting (HTS) power devices such as generators, motors, and power distribution cables. For such large and critical power systems, it is advantageous to design the cryogenic circulation system based on the platform level design constraints to ensure greater resiliency. Utilizing multiple integrated cryocoolers within the cryogenic cooling system increases overall efficiency, resiliency, reconfigurability, simplified designs, and allows maintenance to be performed without shutting off the devices. A novel scheme to integrate multiple cryocoolers in one large heat exchanger is introduced to design efficient, expandable, and resilient integrated cryocooler units. The temperature of the gaseous helium cryogen at the outlet of the cryocooling unit and detailed temperature distribution in the unit are simulated by the finite element method (FEM) using COMSOL. The results provide useful insights in determining the internal structure which can be optimized for the sustainability of the cryocooling system at the required cooling power. The key design factors of an integrated cryocooling system are discussed along with the detailed models and feasibilities of building a high power-dense and resilient HTS power system cooled with an integrated cryocooler system.