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M3Or4N-01: [Invited] HTS Devices and Related Cryogenic Systems for Electric Aircraft and Ships

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High Temperature Superconducting (HTS) power systems are being developed for a variety of applications including the electrical power grid, industrial applications, data centers, high energy physics, electric ships, and electric aircraft. There are some common requirements and design features for HTS devices for all the applications. However, the design requirements for electric transportation applications such as electric aircraft and electric ships need high gravimetric and volumetric power densities. The power density demands require that the HTS generators and motors in electric transportation applications operate at a temperature between 20 and 50 K to compensate for the reduction in critical current density and AC losses under the substantial magnetic fields present in the rotating machines. HTS power distribution cables support high enough current densities when operated at higher temperatures of 40 - 60 K. The challenges with power cables that carry multiple kA are the cable terminations, current leads, and cryogenic interfaces. Innovative designs are needed to address the challenges of low dielectrics and cryogenic thermal designs. Versatile lightweight heat exchangers and secondary cooling loops for effective utilization of the cryogenic cooling power of liquid hydrogen fuel from 20 K to 300 K need to be developed. Cryogenic thermal storage systems are needed for resiliency against unexpected heat loads and to maintain the temperature of some cryogenic components during ground stops. We at the Center for Advanced Power Systems (CAPS) are collaborating with other academic institutions and several small businesses to address the challenges of AC losses in HTS rotating machines and making the interfaces (terminations) for HTS cable systems compact. We have ongoing work on cryogenic dielectric and cooling systems for HTS applications for electric transportation applications. The Presentation will focus on the ongoing research and recent collaborative accomplishments in these areas. Collaborative efforts include superconducting technologies and cryogenics for zero emission electric aircraft.
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